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DIAMONDS IN METEORIC IRON.

Dr. H. C. Hovey in an Article in the Scientific American of Aug. 29th, says: "A remarkable paper was read at the Washington meeting of the A. A. A. S. by Prof. A. E. Foote of Philadelphia, describing a new locality for meteoric iron near Cañon Diablo, Arizona, fragments of which contained diamonds. * * *

Small meteoric fragments, numbering 131 in all, ranging in weight from one-sixteenth of an ounce to six pounds ten ounces, were scattered over an area about a third of a mile in length and 120 feet wide, and extending N.W. and S.E. Exactly in line but about two miles S.E. were found two large masses, one weighing 154 pounds and the other 201 pounds, which were on exhibition, both of them deeply pitted, and the larger one perforated in three places. * * *

About 200 pounds of angular oxidized fragments also of meteoric origin were found near the base of the crater, a few of which showed a greenish stain from oxidized nickel. * * *

A fragment of a mass weighing 40 pounds was examined by Prof. G. A. Koenig, who found it to be extremely hard, a day and a half being taken in making a section. An emery wheel was ruined in trying to polish the section. This led to closer inspection of certain exposed cavities, where small black diamonds were found. * * *

The fact of special interest may be accepted as proved, that diamonds have been found in meteoric fragments. The specimens were carefully examined by the geologists present at the reading of Prof. Foote's paper, and while there were many opinions expressed as to the so-called 'crater,' and as to its relation to the meteor, none doubted the genuineness of the diamonds."

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THE

AMERICAN JOURNAL OF SCIENCE

[THIRD SERIES.]

ART. XXVII.—*Some of the Possibilities of Economic Botany;* by GEORGE LINCOLN GOODALE.

[Presidential address delivered before the American Association for the Advancement of Science, at Washington, August, 1891.]

OUR Association demands of its president, on his retirement from office, some account of matters connected with the department of science in which he is engaged.

But you will naturally expect that, before I enter upon the discharge of this duty, I should present a report respecting the mission with which you entrusted me last year. You desired me to attend the annual meeting of the Australasian Association for the Advancement of Science, and express your good wishes for its success. Compliance with your request did not necessitate any material change in plans formed long ago to visit the South Seas; some of the dates and the sequence of places had to be modified; otherwise the early plans were fully carried out.

I can assure you that it seemed very strange to reverse the seasons, and find mid-summer in January. But in the meeting with our brethren of the southern hemisphere, nothing else was reversed. The official welcome to your representative was as cordial, and the response by the members was as kindly as that which the people in the northern hemisphere would give to any fellow-worker coming from beyond the sea.

The meeting to which I was commissioned was held in January last in the Cathedral city of Christchurch, New Zealand, the seat of Canterbury College.

Considering the distance between the other colonies and New Zealand, the meeting was well attended. From Hobart, Tasmania, to the southern harbor, known as the Bluff, in New Zealand, the sea voyage is only a little short of one thousand miles of rough water. From Sydney in New South Wales to Auckland, New Zealand, it is over twelve hundred miles. If, therefore, one journeys from Adelaide in South Australia, to Christchurch, New Zealand, where the meeting was held he travels by land and by sea over two thousand miles. From Brisbane in Queensland, it is somewhat farther. Although certain concessions are made to the members of the Association, the fares by rail and by steamship are high, so that a journey from any one of the seats of learning in Australia proper to New Zealand is formidable on account of its cost. It is remarkable that so large a number of members should have met together under such circumstances, and it speaks well for the great strength and vigor of the Association.

The Australasian Association is modelled rather more closely after the British Association than is our own. The president delivers his address upon his inauguration. There are no general business meetings, but all the details are attended to by an executive committee answering to our council; none except the members and associates are invited to attend even the sectional meetings and there are some other differences between the three associations. The secretaries stated to me their conviction that their organization and methods are better adapted to their surroundings than ours would be, and all of their arguments seemed cogent. Although the Association has been in existence but three years, it has accomplished great good. It has brought together workers in different fields for conference and mutual benefit; it has diminished misunderstandings, and has strengthened friendships. In short it is doing the same kind of good work that we believe ours is now doing, and in much the same way.

Your message was delivered at the general evening session immediately before the induction of the new officers. The retiring president, Baron von Mueller, and the incoming president Sir James Hector, in welcoming your representative, expressed their pleasure that you should have seen fit to send personal greetings.

In replying to their welcome, I endeavored to convey your felicitations upon the pronounced success of the Association, and your best wishes for a prosperous future. In your name, I extended a cordial invitation to the members to gratify us by their presence at some of our annual meetings, and I have good reason to believe that this invitation will be accepted. I know it will be most thoroughly and hospitably honored by us.

On the morning of the session to which I refer, we received in the daily papers, a cable telegram relative to the Bering Sea difficulties (which were then in an acute stage). In your stead, I ventured to say, "In these days of disquieting dispatches, when there are rumors of trouble between Great Britain and the United States, it is pleasant to think that 'blood is thicker than water.'" This utterance was taken to mean that we are all English-speaking kinsmen, and even before I had finished, the old proverb was received with prolonged applause.

The next meeting of the Australasian Association is to be held in Hobart, the capital of Tasmania, under the presidency of the governor, Sir Robert Hamilton. The energetic secretaries Professor Liversidge, Professor Hutton and Mr. Morton, promise a cordial welcome to any of our members visiting the Association. Should you accept the invitation, you will enjoy every feature of the remarkable island, Tasmania, where the meeting is to be held. You will be delighted by Tasmanian scenery, vegetation and climate, but that which will give you the greatest enjoyment in this as in other English South Sea colonies, is the fact that you are among English-speaking friends half way around the world. You will find that their efficient Association is devoted to the advancement of science and the promotion of sound learning. In short you will be made to feel at home.

The subject which I have selected for the valedictory address deals with certain industrial, commercial and economic questions: nevertheless it lies wholly within the domain of botany. I invite you to examine with me some of the possibilities of economic botany.

Of course, when treating a topic which is so largely speculative as this, it is difficult and unwise to draw a hard and fast line between possibilities and probabilities. Nowadays, possibilities are so often realized rapidly that they become accomplished facts before we are aware.

In asking what are the possibilities that other plants than those we now use may be utilized we enter upon a many-sided inquiry.* Speculation is rife as to the coming man. May we not ask what plants the coming man will use?

There is an enormous disproportion between the total number of species of plants known to botanical science and the number of those which are employed by man.

The species of flowering plants already described and named are about one hundred and seven thousand. Acquisitions from unexplored or imperfectly explored regions may increase the

* For references, notes, etc., see p. 300.

aggregate perhaps one-tenth, so that we are within very safe limits in taking the number of existing species to be somewhat above one hundred and ten thousand.[1]

Now if we should make a comprehensive list of all the flowering plants which are cultivated on what we may call a fairly large scale at the present day, placing therein all food[2] and forage plants, all those which are grown for timber and cabinet woods, for fibres and cordage, for tanning materials, dyes, resins, rubber, gums, oils, perfumes and medicines, we could bring together barely three hundred species. If we should add to this short catalogue all the species, which without cultivation, can be used by man, we should find it considerably lengthened. A great many products of the classes just referred to are derived in commerce from wild plants, but exactly how much their addition would extend the list, it is impossible in the present state of knowledge to determine. Every enumeration of this character is likely to contain errors from two sources: first, it would be sure to contain some species which have outlived their real usefulness, and, secondly, owing to the chaotic condition of the literature of the subject, omissions would occur.

But after all proper exclusions and additions have been made, the total number of species of flowering plants utilized to any considerable extent by man in his civilized state does not exceed, in fact it does not quite reach, one per cent.

The disproportion between the plants which are known and those which are used becomes much greater when we take into account the species of flowerless plants also. Of the five hundred ferns and their allies we employ for other than decorative purposes only five; the mosses and liverworts, roughly estimated at five hundred species, have only four which are directly used by man. There are comparatively few Algae, Fungi, or Lichens which have extended use.

Therefore, when we take the flowering and flowerless together, the percentage of utilized plants falls far below the estimate made for the flowering alone.

Such a ratio between the number of species known and the number used justifies the inquiry which I have proposed for discussion at this time—namely, can the short list of useful plants be increased to advantage? If so, how?

This is a practical question; it is likewise a very old one. In one form or another, by one people or another, it has been asked from early times. In the dawn of civilization, mankind inherited from savage ancestors certain plants, which had been found amenable to simple cultivation, and the products of these plants supplemented the spoils of the chase and of the sea. The question which we ask now was asked then. Wild

plants were examined for new uses; primitive agriculture and horticulture extended their bounds in answer to this inquiry. Age after age has added slowly and cautiously to the list of cultivable and utilizable plants, but the aggregate additions have been as we have seen, comparatively slight.

The question has thus no charm of novelty, but it is as practical to-day as in early ages In fact, at the present time, in view of all the appliances at the command of modern science and under the strong light cast by recent biological and technological research, the inquiry which we propose assumes great importance. One phase of it is being attentively and systematically regarded in the great Experiment Stations, another phase is being studied in the laboratories of Chemistry and Pharmacy, while still another presents itself in the museums of Economic Botany.

Our question may be put in other words, which are even more practical. What present likelihood is there that our tables may, one of these days, have other vegetables, fruits and cereals, than those which we use now? What chance is there that new fibers may supplement or even replace those which we spin and weave, that woven fabrics may take on new vegetable colors, that flowers and leaves may yield new perfumes and flavors? What probability is there that new remedial agents may be found among plants neglected or now wholly unknown? The answer which I shall attempt is not in the nature of a prophecy; it can claim no rank higher than that of a reasonable conjecture.

At the outset it must be said that synthetic chemistry has made and is making some exceedingly short cuts across this field of research, giving us artificial dyes, odors, flavors, and medicinal substances, of such excellence that it sometimes seems as if before long the old-fashioned chemical processes in the plant itself would play only a subordinate part. But although there is no telling where the triumphs of chemical synthesis will end, it is not probable that it will ever interfere essentially with certain classes of economic plants. It is impossible to conceive of a synthetic fiber or a synthetic fruit. Chemistry gives us fruit-ethers and fruit-acids, and after a while may provide us with a true artificial sugar and amorphous starch; but artificial fruits worth the eating or artificial fibers worth the spinning are not coming in our day.

Despite the extraordinary achievements of synthetic chemistry, the world must be content to accept for a long time to come, the results of the intelligent labor of the cultivator of the soil and the explorer of the forest. Improvement of the good plants we now utilize, and the discovery of new ones must remain the care of large numbers of diligent students

and assiduous workmen. So that, in fact, our question resolves itself into this: can these practical investigators hope to make any substantial advance?

It will be well to glance first at the manner in which our wild and cultivated plants have been singled out for use. We shall, in the case of each class, allude to the methods by which the selected plants have been improved, or their products fully utilized. Thus looking the ground over, although not minutely, we can see what new plants are likely to be added to our list. Our illustrations can, at the best, be only fragmentary.

We shall not have time to treat the different divisions of the subject in precisely the proportions which would be demanded by an exhaustive essay; an address on an occasion like this must pass lightly over some matters which other opportunities for discussion could properly examine with great fulness. Unfortunately, some of the minor topics which must be thus passed by, possess considerable popular interest; one of these is the first subordinate question introductory to our task, namely, how were our useful cultivated and wild plants selected for use?

A study of the early history of plants employed for ceremonial purposes, in religious solemnities, in incantations, and for medicinal uses, shows how slender has sometimes been the claim of certain plants to the possession of any real utility. But some of the plants which have been brought to notice in these ways have afterwards been found to be utilizable in some fashion or other. This is often seen in the cases of the plants which have been suggested for medicinal use through the absurd doctrine of signatures.[3]

It seems clear that, except in modern times, useful plants have been selected almost wholly by chance, and it may well be said that a selection by accident is no selection at all. Nowadays, the new selections are based on analogy. One of the most striking illustrations of the modern method is afforded by the utilization of bamboo fiber for electric lamps.

Some of the classes of useful plants must be passed by without present discussion; others alluded to slightly, while still other groups fairly representative of selection and improvement will be more fully described. In this latter class would naturally come, of course, the food-plants known as

I. The Cereals.

Let us look first at these.

The species of grasses which yield these seed-like fruits, or as we might call them for our purpose seeds, are numerous;[4] twenty of them are cultivated largely in the Old World, but

only six of them are likely to be very familiar to you, namely, wheat, rice, barley, oats, rye and maize. The last of these is of American origin, despite doubts which have been cast upon it. It was not known in the Old World until after the discovery of the New. It has probably been very long in cultivation. The others all belong to the Old World. Wheat and barley have been cultivated from the earliest times; according to De Candolle, the chief authority in these matters, about four thousand years. Later came rye and oats, both of which have been known in cultivation for at least two thousand years. Even the shorter of these periods gives time enough for wide variation, and as is to be expected there are numerous varieties of them all. For instance, Vilmorin, in 1880, figured sixty-six varieties of wheat with plainly distinguishable characters.[5]

If the Chinese records are to be trusted, rice has been cultivated for a period much longer than that assigned by our history and traditions to the other cereals, and the varieties are correspondingly numerous. It is said that in Japan above three hundred varieties are grown on irrigated lands, and more than one hundred on uplands.[6]

With the possible exception of rice, not one of the species of cereals is certainly known in the wild state.[7] Now and then specimens have been gathered in the East which can be referred to the probable types from which our varieties have sprung, but doubt has been thrown upon everyone of these cases. It has been shown conclusively that it is easy for a plant to escape from cultivation and persist in its new home even for a long time in a near approximation to cultivated form. Hence, we are forced to receive all statements regarding the wild forms with caution. But it may be safely said that if all the varieties of cereals which we now cultivate were to be swept out of existence, we could hardly know where to turn for wild species with which to begin again. We could not know with certainty.

To bring this fact a little more vividly to our minds, let us suppose a case. Let us imagine that a blight without parallel has brought to extinction all the forms of wheat, rice, rye, oats, barley and maize, now in cultivation, but without affecting the other grasses or any other form of vegetable food. Mankind would be obliged to subsist upon the other kindly fruits of the earth; upon root-crops, tubers, leguminous seeds, and so on. Some of the substitutions might be amusing in any other time than that of a threatened famine. Others would be far from appetizing under any condition, and only a few would be wholly satisfying even to the most pronounced vegetarian. In short, it would seem, from the first, that the cereals fill a place occupied by no other plants. The composition of the grains

is theoretically and practically almost perfect as regards food ratio between the nitrogenous matters and the starch group; and the food value, as it is termed, is high. But aside from these considerations, it would be seen that for safety of preservation through considerable periods, and for convenience of transportation, the cereals take highest rank. Pressure would come from every side to compel us to find equivalents for the lost grains. From this predicament I believe that the well-equipped Experiment Stations and the Agricultural Departments in Europe and America would by and by extricate us. Continuing this hypothetical case, let us next inquire how the Stations would probably go to work in the up-hill task of making partially good a well-nigh irreparable loss.

The whole group of relatives of the lost cereals would be passed in strict review. Size of grain, strength and vigor and plasticity of stock, adaptability to different surroundings, and flexibility in variation would be examined with scrupulous care.

But the range of experiment would, under the circumstances, extend far beyond the relatives of our present cereals. It would embrace an examination of the other grasses which are even now cultivated for their grains, but which are so little known outside of their own limit, that it is a surprise to hear about them. For example, the Millets, great and small, would be investigated. These grains, so little known here, form an important crop in certain parts of the east. One of the leading authorities on the subject[8] states that the Millets constitute "a more important crop" in India "than either Rice or Wheat, and are grown more extensively, being raised from Madras in the south to Rajputana in the north. They occupy about eighty-three per cent of the food-grain area in Bombay and Sinde, forty-one per cent in the Punjab, thirty-nine per cent in the Central Provinces," "in all about thirty million acres."

Having chosen proper subjects for experimenting, the cultivators would make use of certain well-known principles. By simple selection of the more desirable seeds, strains would be secured to suit definite wants, and these strains would be kept as races, or attempts would be made to intensify wished-for characters. By skillful hybridizing of the first, second and higher orders, tendencies to wider variation would be obtained and the process of selection considerably expedited.[9]

It is out of our power to predict how much time would elapse before satisfactory substitutes for our cereals could be found. In the improvement of the grains of grasses other than those which have been very long under cultivation, experiments have been few, scattered and indecisive. Therefore we are as badly off for time-ratios as are the geologists and archæologists, in their statements of elapsed periods. It is

impossible for us to ignore the fact that there appear to be occasions in the life of a species when it seems to be peculiarly susceptible to the influences of its surroundings.[10] A species, like a carefully laden ship, represents a balancing of forces within and without. Disturbance may come through variation from within, as from a shifting of the cargo, or, in some cases from without. We may suppose both forces to be active in producing variation, a change in the internal condition rendering the plant more susceptible to any change in its surroundings. Under the influence of any marked disturbance, a state of unstable equilibrium may be brought about, at which times the species as such is easily acted upon by very slight agencies.

One of the most marked of these derangements is a consequent of cross-breeding within the extreme limits of varieties. The resultant forms in such cases can persist only by close breeding or by propagation from buds or the equivalents of buds. Disturbances like these arise unexpectedly in the ordinary course of nature, giving us sports of various kinds. These critical periods however, are not unwelcome, since skillful cultivators can take advantage of them. In this very field much has been accomplished. An attentive study of the sagacious work done by Thomas Andrew Knight shows to what extent this can be done.[11] But we must confess that it would be absolutely impossible to predict with certainty how long or how short would be the time before new cereals or acceptable equivalents for them would be provided. Upheld by the confidence which I have in the intelligence, ingenuity, and energy of our Experiment Stations, I may say that the time would not probably exceed that of two generations of our race, or half a century.

In now laying aside our hypothetical illustration, I venture to ask why it is that our Experiment Stations and other institutions dealing with plants and their improvement, do not undertake investigations like those which I have sketched? Why are not some of the grasses other than our present cereals studied with reference to their adoption as food grains? One of these species will naturally suggest itself to you all, namely, the Wild Rice of the Lakes.[12] Observations have shown that, were it not for the difficulty of harvesting these grains which fall too easily when they are ripe, they might be utilized. But attentive search might find or educe some variety of *Zizania*, with a more persistent grain and a better yield. There are two of our sea-shore grasses which have excellent grains, but are of small yield. Why are not these, or better ones which might be suggested by observation, taken in hand?

The reason is plain. We are all content to move along in lines of least resistance, and are disinclined to make a fresh start. It is merely leaving well enough alone, and so far as the cereals are concerned it is indeed well enough. The generous grains of modern varieties of wheat and barley compared with the well-preserved charred vestiges found in Greece by Schliemann,[13] and in the lake-dwellings,[14] are satisfactory in every respect. Improvements, however, are making in many directions; and in the cereals we now have, we possess far better and more satisfactory material for further improvement both in quality and as regards range of distribution than we could reasonably hope to have from other grasses.

From the cereals we may turn to the interesting groups of plants comprised under the general term

II. Vegetables.

Under this term it will be convenient for us to include all plants which are employed for culinary purposes, or for table use such as salads and relishes.

The potato and sweet potato, the pumpkin and squash, the red or capsicum peppers, and the tomato, are of American origin.

All the others are, most probably, natives of the Old World. Only one plant coming in this class has been derived from Southern Australasia, namely, New Zealand Spinach, (*Tetragonia.*

Among the vegetables and salad-plants longest in cultivation we may enumerate the following—turnip, onion, cabbage, purslane, the large bean (Faba), chick-pea, lentil and one species of pea, garden pea. To these an antiquity of at least four thousand years is ascribed.

Next to these, in point of age, come the radish, carrot, beet, garlic, garden cress, and celery, lettuce, asparagus and the leek. Three or four leguminous seeds are to be placed in the same category, as are also the black peppers.

Of more recent introduction the most prominent are, the parsnip, oyster plant, parsley, artichoke, endive and spinach.

From these lists I have purposely omitted a few which belong exclusively to the tropics, such as certain yams.

The number of varieties of these vegetables is astounding. It is, of course, impossible to discriminate between closely allied varieties which have been introduced by gardeners and seedsmen under different names, but which are essentially identical, and we must therefore have recourse to a conservative authority, Vilmorin,[15] from whose work a few examples have been selected. The varieties which he accepts are suf-

ficiently well distinguished to admit of description and in most instances of delineation, without any danger of confusion. The potato has, he says, innumerable varieties, of which he accepts forty as easily distinguishable and worthy of a place in a general list, but he adds also a list, comprising, of course, synonyms, of thirty-two French, twenty-six English, nineteen American and eighteen German varieties. The following numbers speak for themselves, all being selected in the same careful manner as those of the potato: celery more than twenty; carrot more than thirty; beet, radish and potato more than forty; lettuce and onion more than fifty; turnip more than seventy; cabbage, kidney bean and garden pea more than one hundred.

The amount of horticultural work which these numbers represent is enormous. Each variety established as a race (that is a variety which comes true to seed) has been evolved by the same sort of patient care and waiting which we have seen is necessary in the case of cereals but the time of waiting has not been as a general thing so long.

You will permit me to quote from Vilmorin[18] also an account of a common plant, which will show how wide is the range of variation and how obscure are the indications in the wild plant of its available possibilities. The example shows how completely hidden are the potential variations useful to mankind.

"Cabbage, a plant which is indigenous in Europe and Western Asia, is one of the vegetables which has been cultivated from the earliest time. The ancients were well acquainted with it, and certainly possessed several varieties of the head-forming kinds. The great antiquity of its culture may be inferred from the immense number of varieties which are now in existence, and from the very important modifications which have been produced in the characteristics in the original or parent plant.

The wild Cabbage, such as it now exists on the coasts of England and France, is a perennial plant with broad-lobed, undulated, thick, smooth leaves, covered with a glaucous bloom. The stem attains a height of from nearly two and a half to over three feet, and bears at the top a spike of yellow or sometimes white flowers. All the cultivated varieties present the same peculiarities in their inflorescence, but up to the time of flowering they exhibit most marked differences from each other and from the original wild plant. In most of the Cabbages, it is chiefly the leaves that are developed by cultivation; these for the most part become imbricated or overlap one another closely, so as to form a more or less compact head, the heart or interior of which is composed of the central undeveloped shoot and the younger leaves next it. The shape of the head is spherical, sometimes flattened, sometimes conical. All the varieties which form heads in this way are known by the general name of Cabbages, while other kinds with

large branching leaves which never form heads are distinguished by the name of Borecole or Kale.

In some kinds, the flower-stems have been so modified by culture as to become transformed into a thick, fleshy tender mass, the growth and enlargement of which are produced at the expense of the flowers which are absorbed and rendered abortive. Such are the Broccolis and Cauliflowers."

But this plant has other transformations.

"In other kinds, the leaves retain their ordinary dimensions, while the stem or principal root has been brought by cultivation to assume the shape of a large ball or turnip, as in the case of the plants known as Kohl-Rabi and Turnip-rooted Cabbage or Swedish Turnip. And lastly, there are varieties in which cultivation and selection have produced modifications in the ribs of the leaves, as in the Couve Tronchuda, or in the axillary shoots (as in Brussels sprouts), or in several organs together, as in the Marrow Kales, and the Neapolitan Curled Kale."

Here are important morphological changes like those to which Professor Bailey has called attention in the case of the tomato.

Suppose we are strolling along the beach at some of the seaside resorts of France, and should fall in with this coarse cruciferous plant, with its sprawling leaves and strong odor. Would there be anything in its appearance to lead us to search for its hidden merit as a food plant? What could we see in it which would give it a preference over a score of other plants at our feet? Again, suppose we are journeying in the high lands of Peru, and should meet with a strong-smelling plant of the Night-shade family, bearing a small irregular fruit, of subacid taste and of peculiar flavor. We will further imagine that the peculiar taste strikes our fancy, and we conceive that the plant has possibilities as a source of food. We should be led by our knowledge of the potato, probably a native of the same region, to think that this allied plant might be safely transferred to a northern climate, but would there be promise of enough future usefulness in such a case as this, to warrant our carrying the plant North as an article of food? Suppose, further, we should ascertain that the fruit in question was relished not only by the natives of its home, but that it had found favor among the tribes of South Mexico and Central America, and had been cultivated by them until it had attained a large size; should we be strengthened in our venture? Let us go one step further still. Suppose that having decided upon the introduction of the plant, and having urged everybody to try it, we should find it discarded as a fruit, but taking a place in gardens as a curiosity under an absurd name, or as a basis

for preserves and pickles; should we not look upon our experiment in the introduction of this new plant as a failure? This is not a hypothetical case.

The Tomato,[17] the plant in question, was cultivated in Europe as long ago as 1554;[18] it was known in Virginia in 1781 and in the Northern States in 1785; but it found its way into favor slowly, even in this land of its origin. A credible witness states that in Salem it was almost impossible to induce people to eat or even taste of the fruit. And yet, as you are well aware, its present cultivation on an enormous scale in Europe and this country is scarcely sufficient to meet the increasing demand.

A plant which belongs to the family of the tomato has been known to the public under the name of the strawberry tomato. The juicy yellow or orange-colored fruit is enclosed in a papery calyx of large size. The descriptions which were published when the plant was placed on the market were attractive, and were not exaggerated to a misleading extent. But, as you all know, the plant never gained any popularity. If we look at these two cases carefully we shall see that what appears to be caprice on the part of the public is at bottom common sense. The cases illustrate as well as any which are at command, the difficulties which surround the whole subject of the introduction of new foods.

Before asking specifically in what direction we shall look for new vegetables I must be pardoned for calling attention, in passing, to a very few of the many which are already in limited use in Europe and this country, but which merit a wider employment. Cardon, or Cardoon; Celeriac, or turnip-rooted celery; Fetticus, or corn-salad; Martynia; Salsify; Sea-kale; and numerous small salads, are examples of neglected treasures of the vegetable garden.

The following which are even less known may be mentioned as fairly promising.[19]

(1) *Arracacia esculenta*, called Arracacha, belonging to the Parsley family. It is extensively cultivated in some of the northern States of South America. The stems are swollen near the base, and produce tuberous enlargements filled with an excellent starch. Although the plant is of comparatively easy cultivation, efforts to introduce it into Europe have not been successful, but it is said to have found favor in both the Indies, and may prove useful in our Southern States.

(2) *Ullucus* or Ollucus, another tuberous-rooted plant from nearly the same region, but belonging to the Beet or Spinach family. It has produced tubers of good size in England, but they are too waxy in consistence to dispute the place of the better tubers of the potato. The plant is worth investigating for our hot dry lands.

(3) A tuber-bearing relative of our common Hedge-nettle, or *Stachys*, is now cultivated on a large scale at Crosnes in France, for the Paris market. Its name in Paris is taken from the locality where it is now grown for use. Although its native country is Japan, it is called by some seedsmen Chinese Artichoke. At the present stage of cultivation, the tubers are small and are rather hard to keep, but it is thought "that both of these defects can be overcome or evaded."[21] Experiments indicate that we have in this species a valuable addition to our vegetables. We must next look at certain other neglected possibilities.

Dr. Edward Palmer,[20] whose energy as a collector and acuteness as an observer are known to you all, has brought together very interesting facts relative to the food-plants of our North American aborigines. Among the plants described by him there are a few which merit careful investigation. Against all of them, however, there lie the objections mentioned before, namely:

(1) The long time required for their improvement, and

(2) The difficulty of making them acceptable to the community, involving

(3) The risk of total and mortifying failure.

In the notes to this address the more prominent of these are enumerated.

In 1854 the late Professor Gray called attention to the remarkable relations which exist between the plants of Japan and those of our Eastern coast. You will remember that he not only proved that the plants of the two regions had a common origin, but also emphasized the fact that many species of the two countries are almost identical. It is to that country which has yielded us so many useful and beautiful plants that we turn for new vegetables to supplement our present food-resources. One of these plants, namely, *Stachys*, has already been mentioned as rather promising. There are others which are worth examination and perhaps acquisition.

One of the most convenient places for a preliminary examination of the vegetables of Japan is at the railroad stations on the longer lines, for instance, that running from Tokio to Kobe. For native consumption there are prepared luncheon boxes of two or three stories, provided with the simple and yet embarrassing chop-sticks. It is worth the shock it causes one's nerves to invest in these boxes and try the vegetable contents. The bits of fish, flesh and fowl which one finds therein can be easily separated and discarded, upon which there will remain a few delicacies. The pervading odor of the box is that of aromatic vinegar. The generous portion of boiled rice is of excellent quality with every grain well softened and distinct, and this

without anything else would suffice for a tolerable meal. In the boxes which have fallen under my observation there were sundry boiled roots, shoots and seeds which were not recognizable by me in their cooked form. Professor Georgeson,[22] formerly of Japan, has kindly identified some of these for me, but he says "there are doubtless many others used occasionally."

One may find sliced Lotus roots, roots of large Burdock, Lily bulbs, shoots of Ginger, pickled green Plums, beans of many sorts, boiled Chestnuts, nuts of the Gingko tree, pickled greens of various kinds, dried cucumbers, and several kinds of seaweeds. Some of the leaves and roots are cooked in much the same manner as beet-roots and beet-leaves are by us, and the general effect is not unappetizing. The boiled shoots are suggestive of only the tougher ends of asparagus. On the whole, I do not look back on Japanese railway luncheons with any longing which would compel me to advocate the indiscriminate introduction of the constituent vegetables here.

But when the same vegetables are served in native inns, under more favorable culinary conditions, without the flavor of vinegar and of the pine wood of the luncheon boxes, they appear to be worthy of a trial in our horticulture, and I therefore deal with one or two in greater detail.

Professor Georgeson, whose advantages for acquiring a knowledge of the useful plants of Japan have been unusually good, has placed me under great obligations by communicating certain facts regarding some of the more promising plants of Japan which are not now used here. It should be said that several of these plants have already attracted the notice of the Agricultural Department in this country.

The Soy Bean (*Glycine hispida*). This species is known here to some extent, but we do not have the early and best varieties. These beans replace meat in the diet of the common people.

Mucuna (*Mucuna capitata*) and Dolichos (*Dolichos cultratus*) are pole beans possessing merit.

Dioscorea; there are several varieties with palatable roots. Years ago one of these was spoken of by the late Dr. Gray, as possessing "excellent roots, if one could only dig them."

Colocasia antiquorum has tuberous roots, which are nutritious.

Conophallus Konjak has a large bulbous root, which is sliced, dried and beaten to a powder. It is an ingredient in cakes.

Aralia cordata is cultivated for the shoots, and used as we use Asparagus.

Œnanthe stolonifera and *Cryptotœnia Canadensis* are palatable salad plants, the former being used also as greens.

There is little hope, if any, that we shall obtain from the hotter climates for our southern territory new species, of merit. The native markets in the tropical cities, like Colombo, Batavia, Singapore and Saigon, are rich in fruits, but outside of the native plants bearing these, nearly all the plants appear to be wholly in established lines of cultivation, such, for instance, as members of the Gourd and Night-shade families.

Before we leave the subject of our coming vegetables, it will be well to note a naïve-caution enjoined by Vilmorin in his work, Les Plantes Potagères.[29]

"Finally," he says, "we conclude the article devoted to each plant with a few remarks on the uses to which it may be applied and on the parts of the plants which are to be so used. In many cases such remarks may be looked upon as idle words, and yet it would sometimes have been useful to have them when new plants were cultivated by us for the first time. For instance, the giant edible Burdock of Japan (*Lappa edulis*) was for a long time served up on our tables only as a wretchedly poor Spinach, because people would cook the leaves, whereas, in its native country, it is only cultivated for its tender fleshy roots."

I trust you are not discouraged at this outlook for our coming vegetables.

Two groups of improvable food-plants may be referred to before we pass to the next class, namely, edible fungi and the beverage plants. All botanists who have given attention to the matter agree with the late Dr. Curtis of North Carolina that we have in the unutilized mushrooms an immense amount of available nutriment of a delicious quality. It is not improbable that other fungi than our common "edible mushroom" will by and by be subjected to careful selection.

The principal beverage-plants, Tea, Coffee and Chocolate, are all attracting the assiduous attention of cultivators. The first of these plants is extending its range at a marvellous rate of rapidity through India and Ceylon; the second is threatened by the pests which have almost exterminated it in Ceylon, but a new species, with crosses therefrom, is promising to resist them successfully; the third, Chocolate, is every year passing into lands farther from its original home. To these have been added the Kola, of a value as yet not wholly determined, and others are to augment the short list.

III. Fruits.

Botanically speaking, the cereal grains of which we have spoken, are true fruits, that is to say, are ripened ovaries, but for all practical purposes they may be regarded as seeds. The

fruits, of which mention is now to be made, are those commonly spoken of in our markets, as fruits.

First of all, attention must be called to the extraordinary changes in the commercial relations of fruits by two direct causes,

(1) The canning industry, and

(2) Swift transportation by steamers and railroads.

The effects of these two agencies are too well known to require more than this passing mention. By them the fruits of the best fruit-growing countries are carried to distant lands in quantities which surprise all who see the statistics for the first time. The ratio of increase is very startling. Take for instance, the figures given by Mr. Morris at the time of the great Colonial and Indian Exhibition, in London. Compare double decades of years.

1845, £886,888.
1865, £3,185,984.
1885, £7,587,523.

In the Colonial Exhibition at London, in 1886, fruits from the remote colonies were exhibited under conditions which proved that, before long, it may be possible to place such delicacies as the Cherimoyer, the Sweet-cup, Sweet-sop, Rambutan, Mango and Mangosteen, at even our most northern seaports. Furthermore, it seems to me likely that with an increase in our knowledge with regard to the microbes which produce decay, we may be able to protect the delicate fruits from injury for any reasonable period. Methods which will supplement refrigeration are sure to come in the very near future, so that even in a country so vast as our own, the most perishable fruits will be transported through its length and breadth without harm.

The canning industry and swift transportation are likely to diminish zeal in searching for new fruits, since, as we have seen in the case of the cereals, we are prone to move in lines of least resistance and leave well enough alone.

To what extent are our present fruits likely to be improved? Even those who have watched the improvement in the quality of some of our fruits, like oranges, can hardly realize how great has been the improvement within historic times in the character of certain pears, apples, and so on.

The term historic is used advisedly, for there are pre-historic fruits which might serve as a point of departure in the consideration of the question. In the ruins of the lake-dwellings in Switzerland,[24] charred apples have been found, which are

in some cases, plainly of small size, hardly equalling ordinary crab apples. But, as Dr. Sturtevant has shown, in certain directions, there has been no marked change of type, the change is in quality.

In comparing the earlier descriptions of fruits with modern accounts it is well to remember that the high standards by which fruits are now judged are of recent establishment. Fruits which would once have been esteemed excellent, would to-day be passed by as unworthy of regard.

It seems probable that the list of seedless fruits will be materially lengthened, provided our experimental horticulturists make use of the material at their command. The common fruits which have very few or no seeds are the banana, pineapple and certain oranges. Others mentioned by Mr. Darwin as well known are the bread-fruit, pomegranate, azarole or Neapolitan medlar, and date palms. In commenting upon these fruits, Mr. Darwin[25] says that most horticulturists "look at the great size and anomalous development of the fruit as the cause and sterility as the result," but he holds the opposite view as more probable, that is, that the sterility, coming about gradually, leaves free for other growth the abundant supply of building material which the forming seed would otherwise have. He admits, however, that "there is an antagonism between the two forms of reproduction, by seeds and by buds when either is carried to an extreme degree which is independent of any incipient sterility."

Most plant-hybrids are relatively infertile, but by no means wholly sterile. With this sterility there is generally augmented vegetative vigor, as shown by Nägeli. Partial or complete sterility and corresponding luxuriance of root, stem, leaves and flower, may come about in other obscure ways, and such cases are familiar to botanists.[10] Now it seems highly probable that either by hybridizing directed to this special end, or by careful selection of forms indicating this tendency to the correlated changes, we may succeed in obtaining important additions to our seedless or nearly seedless plants. Whether the ultimate profit would be large enough to pay for the time and labor involved is a question which we need not enter into; there appears to me no reasonable doubt that such efforts would be successful. There is no reason in the nature of things why we should not have strawberries without the so-called seeds; blackberries and raspberries, with only delicious pulp; and large grapes as free from seeds as the small ones which we call "currants" but which are really grapes from Corinth.

These and the coreless apples and pears of the future, the stoneless cherries and plums, like the common fruits before

mentioned must be propagated by bud division, and be open to the tendency to diminished strength said to be the consequence of continued bud-propagation. But this bridge need not be crossed until we come to it. Bananas have been perpetuated in this way for many centuries, and pineapples since the discovery of America, so that the borrowed trouble alluded to is not threatening. First we must catch our seedless fruits.

Which of our wild fruits are promising subjects for selection and cultivation?

Mr. Crozier of Michigan has pointed out[26] the direction in which this research may prove most profitable. He enumerates many of our small fruits and nuts which can be improved.

Another of our most careful and successful horticulturists believes that the common blueberry and its allies are very suitable for this purpose and offer good material for experimenting. The sugar-plum, or so-called shadbush, has been improved in many particulars, and others can be added to this list.

But again we turn very naturally to Japan, the country from which our gardens have received many treasures. Referring once more to Professor Georgeson's studies,[27] we must mention the varieties of Japanese apples, pears, peaches, plums, cherries and persimmons. The persimmons are already well-known in some parts of our country, under the name "kaki" and they will doubtless make rapid progress in popular favor.

The following are less familiar: *Actinidia arguta* and *volubilis*, with delicious berries;

Stauntonia, an evergreeen vine yielding a palatable fruit;

Myrica rubra, a small tree with an acidulous juicy fruit;

Elæagnus umbellata, with berries for preserves.

The active and discriminating horticultural journals in America and Europe are alive to the possibilities of new Japanese fruits, and it cannot be very long before our list is considerably increased.

It is absolutely necessary to recollect that in most cases variations are slight. Dr. Masters and Mr. Darwin have called attention to this and have adduced many illustrations, all of which show the necessity of extreme patience and caution. The general student curious in such matters can have hardly any task more instructive than the detection of the variations in such common plants as the blueberry, the wild cherry, or the like. It is an excellent preparation for a practical study of the variations in our wild fruits suitable for selection.

It was held by the late Dr. Gray that the variations in nature by which species have been evolved were led along useful lines, a view which Mr. Darwin regretted he could not entertain. However this may be, all acknowledge that by the hand

of the cultivator variations can be led along useful lines; and furthermore the hand which selects must uphold them in their unequal strife. In other words it is one thing to select a variety and another to assist it in maintaining its hold upon existence. Without the constant help of the cultivator who selects the useful variety, there comes a reversion to the ordinary specific type which is fitted to cope with its surroundings.

I think you can agree with me that the prospect for new fruits and for improvements in our established favorites is fairly good.

IV. Timbers and Cabinet Woods.

Can we look for new timbers and cabinet woods? Comparatively few of those in common use are of recent introduction. Attempts have been made to bring into great prominence some of the excellent trees of India and Australia which furnish wood of much beauty and timber of the best quality. A large proportion of all the timbers of the South Seas are characterized by remarkable firmness of texture and high specific gravity.[28] The same is noticed in many of the woods of the Indies. A few of the heavier and denser sorts, like Jarrah, of West Australia, and Sabicu of the Caribbean Islands, have met with deserved favor in England, but the cost of transportation militates against them. It is a fair question whether, in certain parts of our country, these trees and others which can be utilized for veneers, may not be cultivated to advantage. Attention should be again called to the fact that many plants succeed far better in localities which are remote from their origin but where they find conditions substantially like those which they have left. This fact, to which we must again refer in detail with regard to certain other classes of plants, may have some bearing upon the introduction of new timber trees. Certain drawbacks exist with regard to the timber of some of the more rapidly growing hard-wood trees which have prevented their taking a high place in the scale of values in mechanical engineering.

One of the most useful soft-wooded trees in the world is the Kauri. It is restricted in its range to a comparatively small area in the North Island of New Zealand. It is now being cut down with a recklessness which is as prodigal and shameful as that which has marked our own treatment of forests here. It should be said, however, that this destruction is under protest, in spite of which it would seem to be a question of only a few years when the great Kauri groves of New Zealand will be a thing of the past. Our energetic Forest Department has on its hands problems just like this which perplexes one of the new lands of the South. The task in

both cases is double: to preserve the old treasures and to bring in new.

The energy shown by Baron von Mueller, the renowned Government Botanist of Victoria and by various Forest departments in encouraging the cultivation of timber trees will assuredly meet with success; one can hardly hope that this success will appear fully demonstrated in the lifetime of those now living, but I cannot think that many years will pass before the promoters of such enterprises may take fresh courage.

In a modest structure in the City of Sydney, New South Wales, Mr. Maiden[28] has brought together, under great difficulties, a large collection of the useful products of the vegetable kingdom as represented in Australia. It is impossible to look at the collection of woods in that Museum or at the similar and more showy one in Kew, without believing that the field of forest culture must receive rich material from the Southern hemisphere.

Before leaving this part of our subject, it may be well to take some illustrations in passing, to show how important is the influence exerted upon the utilization of vegetable products by causes which may, at first, strike one as being rather remote.

(1) Photography makes use of the effect of light on chromatized gelatin to produce under a negative the basis of relief plates for engraving. The degree of excellence reached in modifications of this simple device has distinctly threatened the very existence of wood engraving, and hence follows a diminished degree of interest in box-wood and its substitutes.

(2) Iron, and in its turn steel, is used in ship-building and this renders of greatly diminished interest all questions which concern the choice of the different oaks, and similar woods:

(3) But on the other hand there is increased activity in certain directions, best illustrated by the extraordinary develment of the chemical methods for manufacturing wood pulp. By the improved processes, strong fibers suitable for fine felting on the screen and fit for the best grades of certain lines of paper are given to us from rather inferior sorts of wood. He would be a rash prophet who should venture to predict what will be the future of this wonderful industry, but it is plain that the time is not far distant when acres now worthless may be covered by trees under cultivation growing for the pulp-maker.

There is no department of Economic Botany more promising in immediate results than that of Arboriculture.

V. Vegetable Fibers.

The vegetable fibers known to commerce are either plant hairs, of which we take cotton as the type, or filaments of

bast-tissue, represented by flax. No new plant hairs have been suggested which can compete in any way for spinning with those yielded by the species of Gossypium, or cotton, but experiments more or less systematic and thorough are being carried on with regard to the improvement of the varieties of the species. Plant hairs for the stuffing of cushions and pillows need not be referred to in connection with this subject.

Countless sorts of plants have been suggested as sources of good bast-fibers for spinning and for cordage, and many of these make capital substitutes for those already in the factories. But the questions of cheapness of production, and of subsequent preparation for use, have thus far militated against success. There may be much difference between the profits promised by a laboratory experiment and those resulting from the same process conducted on a commercial scale. The existence of such differences has been the rock on which many enterprises seeking to introduce new fibers have been wrecked.

In dismissing this portion of our subject it may be said that a process for separating fine fibers from undesirable structural elements and from resin-like substances which accompany them, is a great desideratum. If this were supplied, many new species would assume great prominence at once.

VI. Tanning Materials.

What new tanning materials can be confidently sought for? In his "Useful Native Plants of Australia," Mr. Maiden[28] describes over thirty species of "Wattles" or Acacias, and about half as many Eucalypts, which have been examined for the amount of tanning material contained in the bark. In all, 87 Australian species have been under examination. Besides this, much has been done looking in the same direction at the suggestion and under the direction of Baron von Mueller, of Victoria. This serves to indicate how great is the interest in this subject, and how wide is the field in our own country for the introduction of new tanning plants.

It seems highly probable, however, that artificial tanning substances will at no distant day replace the crude matters now employed.

VII. Resins, Etc.

Resins, oils, gums and medicines from the vegetable kingdom would next engage our attention if they did not seem rather too technical for this occasion, and to possess an interest on the whole somewhat too limited. But an allied substance may serve to represent this class of products and indicate the drift of present research.

India Rubber.[19]—Under this term are included numerous substances which possess a physical and chemical resemblance to each other. An Indian Ficus, the early source of supply, soon became inadequate to furnish the quantity used in the arts even when the manipulation of rubber was almost unknown. Later, supplies came from *Hevea* of Brazil, generally known as Para rubber, and from *Castilloa*, sometimes called Central American Rubber, and from *Manihot Glaziovii* Ceara rubber. Not only are these plants now successfully cultivated in experimental gardens in the Tropics, but many other rubber-yielding species have been added to the list. The Landolphias are among the most promising of the whole: these are the African rubbers. Now in addition to these which are the chief source of supply, we have *Willughbeia*, from the Malayan Peninsula, *Leuconotis*, *Chilocarpus*, *Alstonia*, *Forsteronia*, and a species of a genus formerly known as *Urostigma*, but now united with *Ficus*. These names, which have little significance as they are here pronounced in passing, are given now merely to impress upon our minds the fact that the sources of a single commercial article may be exceedingly diverse. Under these circumstances search is being made not only for the best varieties of these species but for new species as well.

There are few excursions in the Tropics which possess greater interest to a botanist who cares for the industrial aspects of plants than the walks through the Gardens at Buitenzorg in Java and at Singapore. At both these stations the experimental Gardens lie at some distance from the great gardens which the tourist is expected to visit, but the exertion well repays him for all discomfort. Under the almost vertical rays of the sun, are here gathered the rubber-yielding plants from different countries, all growing under conditions favorable for decisions as to their relative value. At Buitenzorg a well-equipped laboratory stands ready to answer practical questions as to quality and composition of their products, and year by year the search extends.

I mention this not as an isolated example of what is being accomplished in Commercial Botany, but as a fair illustration of the thoroughness with which the problems are being attacked. It should be further stated that at the Garden in question assiduous students of the subject are eagerly welcomed and are provided with all needed appliances for carrying on technical, chemical and pharmaceutical investigations. Therefore I am justified in saying that there is every reason for believing that in the very near future new sources of our most important products will be opened up, and new areas placed under successful cultivation.

At this point, attention must be called to a very modest and convenient handbook on the Commercial Botany of the Nine-

teenth Century by Mr. Jackson of the Botanical Museum attached to the Royal Gardens, Kew, which not only embodies a great amount of well-arranged information relative to the new useful plants, but is, at the same time, a record of the existing state of things in all these departments of activity.

VIII. Fragrant Plants.

Another illustration of our subject might be drawn from a class of plants which repays close study from a biological point of view, namely, those which yield perfumes.

In speaking of the future of our fragrant plants we must distinguish between those of commercial value and those of purely horticultural interest. The former will be less and less cultivated in proportion as synthetic chemistry by its manufacture of perfumes replaces the natural by the artificial products, for example, Coumarin, Vanillin, Nerolin, Heliotropin, and even Oil of Wintergreen.

But do not understand me as intimating that Chemistry can ever furnish substitutes for living fragrant plants. Our gardens will always be sweetened by them, and the possibilities in this direction will continue to extend both by contributions from abroad and by improvement in our present cultivated varieties. Among the foreign acquisitions are the fragrant species of *Andropogon*. Who would suspect that the tropical relatives of our sand-loving grasses are of high commercial value as sources of perfumery oils?

The utility to the plant of fragrance in the flower and the relation of this to cross-fertilization, are apparent to even a casual observer. But the fragrance of an aromatic leaf does not always give us the reason for its being.

It has been suggested for certain cases that the volatile oils escaping from the plants in question may, by absorption, exert a direct influence in mitigating the fierceness of action of the sun's rays. Other explanations have also been made, some of which are even more fanciful than the last.

When, however, one has seen that the aromatic plants of Australia are almost free from attacks of insects and fungi, and has learned to look on the impregnating substances in some cases as protective against predatory insects and small foes of all kinds, and in others as fungicidal, he is tempted to ask whether all the substances of marked odor which we find in certain groups of plants may not play a similar rôle.

It is a fact of great interest to the surgeon that in many plants there is associated with the fragrant principle a marked antiseptic or fungicidal quality; conspicuous examples of this are afforded by species of *Eucalyptus*, yielding Eucalyptol, *Styrax*, yielding Styrone, *Thymus* yielding Thymol. It is inter-

esting to note, too, that some of these most modern antiseptics were important constituents in the balsamic vulneraries of the earliest surgery.

IX. Florists' Plants.

Florists' plants and the floral fashions of the future constitute an engaging subject which we can touch only lightly. It is reasonably clear that while the old favorite species will hold their ground in the guise of improved varieties, the new introductions will come in the shape of plants with flowering branches which retain their blossoms for a somewhat long period, and especially those in which the flowers precede the leaves. In short the next real fashion in our gardens is probably to be the flowering shrub and flowering tree, like those which are such favorites in the country from which the Western world has gladly taken the gift of the Chrysanthemum.[29]

Twice each year of late, a reception has been held by the Emperor and Empress of Japan. The receptions are in autumn and in the spring. That in the autumn, popularly known as the Emperor's reception, has for its floral decorations the myriad forms of the national flower, the chrysanthemum; that which is given in spring, the Empress' reception, comes when the cherry blossoms are at their best. One has little idea of the wealth of beauty in masses of flowering shrubs and trees, until he has seen the floral displays in the Imperial Gardens and the Temple grounds in Tokio.

To Japan[29] and China also, we are indebted for many of the choicest plants of our gardens, but the supply of species is by no means exhausted. By far the larger number of the desirable plants have already found their way into the hands of cultivators, but often under conditions which have restricted their dissemination through the flower-loving community. There are many which ought to be widely known, especially the fascinating dwarf shrubs and dwarf trees of the far East, which are sure to find sooner or later a warm welcome among us.

X. Forage Plants.

Next to the food plants for man, there is no single class of commercial plants of greater interest than the food-plants for flocks and herds. Forage plants, wild and cultivated, are among the most important and highly valued resources of vast areas. No single question is of more vital consequence to our farthest west and southwest.

It so happens that the plants on which the pastoralist relies grow or are grown on soil of inferior value to the agriculturist. Even soil which is almost sterile may possess vegetation on which flocks and herds may graze, and, further, these animals may thrive in districts where the vegetation appears at first

sight too scanty or too forbidding, even to support life. There are immense districts in parts of the Australian continent where flocks are kept on plants so dry and desert-like that an inexperienced person would pass them by as not fit for his sheep, and yet, as Mr. Samuel Dixon[30] has well shown, these plants are of high nutritive value and are attractive to flocks.

Relegating to the notes to be published with this address brief descriptions of a few of the fodder plants suggested for use in dry districts, I shall now mention the salt-bushes of various sorts, and the allied desert plants of Australia as worth a careful trial on some of our very dry regions in the farthest west. There are numerous other excellent fodder plants adapted to dry but not parched areas which can be brought in from the corresponding districts of the southern hemisphere and from the East.

At an earlier stage of this address, I have had occasion to refer to Baron von Mueller, whose efforts looking towards the introduction of useful plants into Australasia have been aided largely by his convenient treatise on economic plants.[o] It may be said in connection with the fodder plants, especially, that much which the Baron has written can be applied *mutatis mutandis* to parts of our own country.

The important subject of introducing fodder plants has been purposely reserved to the last because it permits us to examine a practical point of great interest. This is the caution which it is thought necessary to exercise when a species is transferred by our own choice from one country to another. I say, by our choice, for whether we wish it or not certain plants will introduce themselves. In these days of frequent and intimate intercommunication between different countries, the exclusion of foreign plants is simply impossible. Our common weeds are striking illustrations of the readiness with which plants of one country make for themselves a home in another.[31] All but two of the prominent weeds of the eastern States are foreign intruders.

There are all grades of persistence in these immigrants. Near the ballast grounds of every harbor, or the fields close by woolen and paper mills where foreign stock is used, you will observe many foreign plants which have been introduced by seed. For many of these you will search in vain a second year. A few others persist for a year or two longer, but with uncertain tenure of the land which they have invaded: others still have come to stay. But happily some of the intruders which seem at first to gain a firm foot-hold, lose their ground after a while. We have a conspicuous example of this in a hawkweed, which was very threatening in New England two years ago, but is now relaxing its hold.

Another illustration is afforded by a water-plant which we have given to the old world. This plant, called in our botanies *Anacharis*, or *Elodea*, is so far as I am aware, not troublesome in our ponds and water-ways, but when it was carried to England, perhaps as a plant for the aquarium, it was thrown into streams and rivers with a free hand. It spread with remarkable rapidity and became such an unmitigated nuisance that it was called a curse. Efforts to extirpate it merely increased its rate of growth. Its days of mischief are however nearly over, or seem to be drawing to a close, at least so Mr. Lynch of the Botanic Garden in Cambridge, England, and others of my informants think. The history of the plant shows that even under conditions which so far as we can see, are identical with those under which the plant grew in its home, it may for a time take a fresh lease of life and thrive with an undreamed-of energy.

What did *Anacharis* find in the waters of England and the continent that it did not have at home, and why should its energy begin to wane now?

In Australasia one of the most striking of these intruders is Sweet-briar. Introduced as a hedge plant it has run over certain lands like a weed, and disputes every acre of some arable plats. From the facility with which it is propagated, it is almost ineradicable. There is something astounding in the manner in which it gains and holds its ground. Gorse and brambles and thistles are troublesome in some localities, and they prove much less easy to control than in Europe. The effect produced on the mind of the colonist by these intruding pests, is everywhere the same. Whenever in an examination of the plants likely to be worthy of trial in our American dry lands, the subject was mentioned by me to Australians, I was always enjoined to be cautious as to what plants I might suggest for introduction from their country into our own. My good friends insisted that it was bad enough to have as pests the plants which come in without our planning or choice, and this caution seems to me one which should not be forgotten.

It would take us too far from our path to inquire what can be the possible reasons for such increase of vigor and fertility in plants which are transferred to a new home. We should have to examine all the suggestions which have been made, such as fresh soil, new skies, more efficient animal friends, or less destructive enemies. We should be obliged also to see whether the possible wearing out of the energy of some of these plants after a time, might not be attributable to the decadence of vigor through uninterrupted bud-propagation, and we should have to allude to many other questions allied to these. But for this time fails.

Lack of time also renders it impossible to deal with the questions which attach themselves to our main question, especially as to the limits of effect which cultivation may produce. We cannot touch the problem of inheritance of acquired peculiarities, or the manner in which cultivation predisposes the plant to innumerable modifications. Two of these modifications may be mentioned in passing, because they serve to exemplify the practical character of our subject.

Cultivation brings about in plants very curious morphological changes. For example, in the case of a well known vegetable the number of metamorphosed type-leaves forming the ovary is two, and yet under cultivation, the number increases irregularly until the full number of units in the type of the flower is reached. Professor Bailey of Cornell has called attention to some further interesting changes in the tomato, but the one mentioned suffices to illustrate the direction of variation which plants under cultivation are apt to take. Monstrosities are very apt to occur in cultivated plants, and under certain conditions may be perpetuated in succeeding generations, thus widening the field from which utilizable plants may be taken.

Another case of change produced by cultivation is likewise as yet wholly unexplained, although much studied, namely the mutual interaction of scion and stock in grafting, budding, and the like. It is probable that a further investigation of this subject may yet throw light on new possibilities in plants.

We have now arrived at the most practical question of all, namely—

In what way can the range of commercial botany be extended? In what manner or by what means can the introduction of new species be hastened?

It is possible that some of you are aware of the great amount of uncoördinated work which has been done and is now in hand in the direction of bringing in new plants.

The competition between the importers of new plants is so great both in the Old World and the New that a very large proportion of the species which would naturally commend themselves for the use of florists, for the adornment of greenhouses, or for commercial ends, have been at one time or another brought before the public or are being accumulated in stock. The same is true although to a less extent with regard to useful vegetables and fruit. Hardly one of those which we can suggest as desirable for trial, has not already been investigated in Europe or this country, and reported on. The pages of our chemical, pharmaceutical, medical, horticultural, agricultural and trade journals, especially those of high grade, contain a wealth of material of this character.

But what is needed is this, that the promising plants should be systematically investigated under exhaustive conditions. It is not enough that an enthusiast here, or an amateur there should give a plant a trial under imperfectly understood conditions, and then report success or failure. The work should be thorough and every question answered categorically, so that we might be placed in possession of all the facts relative to the object experimented upon. But such an undertaking requires the coöperation of many different agencies. I shall venture to mention some of these.

In the first place,—Botanic Gardens amply endowed for research. The Arnold Arboretum, the Shaw Garden, and the Washington Experimental Garden, are American illustrations of what is needed for this purpose. University gardens have their place in instruction, but cannot wisely undertake this kind of work.

In the second place,—Museums and Laboratories of Economic Botany. Much good work in this direction has been done in this country by the National Museum and by the department in charge[33] of the investigation of new plants. We need institutions like those at Kew in England, and at Buitenzorg in Java, which keep in close touch with all the world. The founding of an establishment on a scale of magnitude commensurate with the greatness and needs of our country is an undertaking which waits for some one of our wealthy men.

In the third place,—Experiment Stations. These may, within the proper limits of their sphere of action, extend the study of plants beyond the established varieties to the species, and beyond the species to equivalent species in other genera. It is a matter of regret that so much of the energy displayed in these stations in this country, and we may say abroad, has not been more economically directed.

Great economy of energy must result from the recent change by which coördination of action is assured. The influence which the stations must exert on the welfare of our country, and the development of its resources is incalculable.

In the last place, but by no means least, the coöperation of all who are interested in scientific matters, through their observation of isolated and associated phenomena connected with plants of supposed utility, and by the cultivation of such plants by private individuals, unconnected with any State, governmental, or academic institutions.

By these agencies, wisely directed and energetically employed, the domains of commercial and industrial botany, will be enlarged. To some of the possible results in these domains, I have endeavored to call your attention.

Notes.

[0] The following are among the more useful works of a general character, dealing with the subject. Others are referred to either in the text or notes. The reader may consult also the list of works on Economic Botany in the catalogue published by the Linnæan Society.

Select Extra-tropical Plants, readily eligible for industrial culture or naturalization, with indications of their native countries and some of their uses. By Baron Ferd. von Mueller, K.C.M.G., F.R.S., etc, Government Botanist for Victoria. (Melbourne), 1888. Seventh edition, revised and enlarged.

At the close of his treatise on industrial plants, Baron von Mueller has grouped the genera indicating the different classes of useful products in such a manner that we can ascertain the respective numbers belonging to the genera. Of course many of these genera figure in more than one category.

He has also arranged the plants according to the countries *naturally producing them.*

Useful Native Plants of Australia, (including Tasmania). By J. H. Maiden, F.L.S., Curator of the Technological Museum of New South Wales, Sydney. (Sydney), 1889.

See also note 19.

Handbook of Commercial Geography. By Geo. G. Chisholm, M.A., B.Sc. London, 1889.

New Commercial Plants with directions how to grow them to the best advantage. By Thomas Christy (London), Christy and Co.

Dictionary of popular names of the plants which furnish the natural and acquired wants of man. By John Smith, A.L.S. (London), 1882.

Cultivated Plants. Their propagation and improvement. By F. W. Burbage. (London), 1877.

The Wanderings of Plants and animals from their first home. By Victor Hehn, edited by James Steven Stallybrass, (London) 1885.

Researches into the Early History of Mankind, and the Development of Civilization. By Edward B. Tylor, D.C.L., LL.D., F.R.S., 1878.

[1] The number of species of Phænogamia has been given by many writers as not far from 150,000. But the total number of species recognized by Bentham and Hooker in the Genera Plantarum (Durand's Index) is 100,220, in 210 Natural Orders and 8,417 genera.

[2] Dr. E. Lewis Sturtevant, to whose kindness I am indebted for great assistance in the matter of references has placed at my disposal many of his notes on edible plants, etc. From his enumeration it appears that if we count all the plants which have been cultivated for food at one time or another, the list contains 1,192 species, but if we count all the plants which "either habitually or during famine periods are recorded to have been eaten," we obtain a list of no less than 4,690 species, or about three and one-half per cent of all known species of plants. But, as Sir Joseph Hooker has said, the products of many plants though eatable, are not fit to eat.

[3] The Folk-Lore of Plants. By T. F. Thiselton Dyer, 1889.

[4] In Dr. Sturtevant's list 88 species of Gramineæ are counted as food-plants under cultivation, while the number of species in this order which can be or have been utilized as food amounts to 146. Our smaller number 20 comprises only those which have been grown on a large scale anywhere.

[5] "In Agricultural Museum at Poppelsdorf, 600 varieties are exhibited."

[6] E. L. S. in letter. Quoted from Seedsman's catalogue.

[7] The best account of the early history of these and other cultivated plants can be found in the classical work of De Candolle "*Origine des Plantes Cultivées* (Paris) translated in the International series. *History of Cultivated Plants*, (N. Y.) The reader should consult also Darwin's *Animals and Plants under Domestication.*

[8] *Food-grains of India*. A. H. Church, London, 1886, p. 34. In this instructive work the reader will find much information regarding the less common articles of food Of *Panicum frumentaceum* Professor Georgeson states in a letter that it is grown in Japan for its grain which is used for food, but here would take rank as a fodder plant.

[9] In order to avoid possible misapprehension, it should be stated that there are a few persons who hold that at least some of our cereals, and other cultivated plants, for that matter, have not undergone material improvement but are essentially unmodified progeny. Under this view, if we could look back into the farthest past, we should see our cereals growing wild and in such admirable condition that we should unhesitatingly select them for immediate use. This extreme position is untenable.

Again, there are a few extremists who hold that some plants under cultivation have reached their culminating point, and must now remain stationary or begin to retrograde.

[10] Gray's Botanical Text Book. Vols. i and ii.

[11] *A Selection from the Physiological and Horticultural Papers*, published in the Transactions of the Royal and Horticultural Societies, by the late THOMAS ANDREW KNIGHT, Esq., President of the Hort. Soc. London, (London) 1841.

[12] *Illustrations of the Manners and Customs and Condition of the North American Indians.* By GEORGE CATLIN, London, 1876. A reprint of the account published in 1841 of travels in 1832–40.

"Plate 278 is a party of Sioux, in bark canoes (purchased of the Chippewas), gathering the wild rice, which grows in immense fields around the shores of the rivers and lakes of these northern regions, and used by the Indians as an article of food. The mode of gathering it is curious and, as seen in the drawing, one woman paddles the canoe, whilst another with a stick in each hand, bends the rice over the canoe with one, and strikes it with the other, which shakes it into the canoe, which is constantly moving along until it is filled." Vol. ii, p. 208.

[13] Schliemann's carbonized specimens exhumed in Greece are said to be "very hard, fine-grained, sharp, very flat on grooved side, different from any wheats now known." Am. Antiq., 1880, 66.

The carbonized grains in the Peabody Museum at Cambridge, Mass., are small.

[14] *Prehistoric Times* as illustrated by Ancient Remains and the manners and customs of modern savages. By JOHN LUBBOCK, Bart., (New York), 4th edn., 1886.

"Three varieties of wheat were cultivated by the Lake Dwellers, who also possessed two kinds of barley and two of millet. Of these the most ancient and most important were the six-rowed barley and small "Lake Dwellers'" wheat. The discovery of Egyptian wheat (*Triticum turgidum*), at Wangen and Robenhausen, is particularly interesting. Oats were cultivated during the bronze age, but are absent from all the stone age villages Rye was also unknown," p. 216.

"Wheat is most common, having been discovered at Merlen, Moosseedorf and Wangen. At the latter place, indeed, many bushels of it were found, the grains being in large thick lumps. In other cases, the grains are free, and without chaff, resembling our present wheat in size and form, while more rarely they are still in the ear." 115 species of plants have been identified. Heer, Keller.

[15] *Les Plantes Potagères*, VILMORIN, Paris. Translated into English under the direction of W. Robinson, Editor of the (London) "Garden," 1885, and entitled *The Vegetable Garden.*

[16] l. c., English Edn., p 104.

[17] According to notes made by Mr. Manning, Sec. Massachusetts Horticultural Society, (Hist. Mass. Hort. Society) the tomato was introduced into Salem, Mass., about 1802 by Michele Felice Corné, an Italian painter, but he found it difficult to persuade people even to taste the fruit (Felt's Annals of Salem, vol. ii, 631). It was said to have been introduced into Philadelphia by a French refugee from San Domingo in 1798. It was used as an article of food in New Orleans in 1812 but was not sold in the markets of Philadelphia until 1829. It did not come into general use in the north until some years after the last named date.

[18] "In Spain and those hot regions, they use to eat the (Love) apples prepared and boiled with pepper, salt, and olives; but they yield very little nourishment to the bodies, and the same nought and corrupt. Likewise they doe eat the apples with oile, vinegar, and pepper mixed together for sauce to their meat even as we in these Cold Countries do Mustard." GERARD'S *Herbal*, 346.

[19] *Commercial Botany of the Nineteenth Century.* By JOHN R. JACKSON, A.L.S. Cassell and Company, London, 1890.

Mr. Jackson, who is the Curator of the Museums, Royal Gardens, Kew. has embodied in this treatise a great amount of valuable information, well arranged for ready reference.

[20] *Department of Agriculture Report* for 1870, p. 404–428. Only those are here copied from Dr. Palmer's list which he expressly states are extensively used.

Ground-nut (*Apios tuberosa*); *Aesculus Californica; Agave Americana; Nuphar advena;* Prairie-potato, (*Psoralea esculenta*); *Scirpus lacustris; Sagittaria variabilis;* Kamass-root (*Camassia esculenta*); *Solanum Fendleri* (supposed by him to be the original of the cultivated potato); Acorns of various sort; Mesquite, (*Algarobia glandulosa*); *Juniperus occidentalis;* Nuts of *Carya, Juglans,* etc.; Screw-bean (*Strombocarpus pubescens*); various Cactaceæ; *Yucca;* Cherries and many wild berries; *Chenopodium album,* etc.

Psoralea esculenta = prairie potato, or Bread-root. Palmer in Agl. Report, 1870, p. 402.

The following from CATLIN, l. c., i, p. 122:

"Corn and dried meat are generally laid in the fall, in sufficient quantities to support them through the winter. These are the principal articles of food during that long and inclement season; and in addition to them, they oftentimes have in store great quantities of dried squashes, and dried 'pommes blanches,' a kind of turnip which grows in great abundance in those regions. . . . . These are dried in great quantities and pounded into a sort of meal and cooked with dried meat and corn. Great quantities also are dried and laid away in store for the winter season, such as buffalo berries, service berries, strawberries, and wild plums."

"In addition to this we had the luxury of service berries without stint; and the buffalo bushes, which are peculiar to these northern regions, lined the banks of the river and the defiles in the bluffs, sometimes for miles together, forming almost impassible hedges, so loaded with the weight of their fruit that their boughs everywhere gracefully bending down or resting on the ground. This last shrub (*Shepherdia*), which may be said to be the most beautiful ornament that decks out the wild prairies, forms a striking contrast to the rest of the foliage, from the blue appearance of its leaves by which it can be distinguished for miles in distance. The fruit which it produces in such incredible profusion, hanging in clusters to every limb and to every twig, is about the size of ordinary currants and not unlike them in color and even in flavor; being exceeding acid, almost unpalatable until they are bitten by frost of autumn, when they are sweetened and their flavor delicious, having to the taste much the character of grapes, and I am almost to think would produce excellent wine." GEORGE CATLIN'S *Illustrations and manners, customs, and condition of the North American Indians,* p. 72, vol. i.

For much relative to the food of our aborigines, especially of the western coast, consult The Native Races of the Pacific States of North America. By H. H. Bancroft. (New York), 1875. The following from vol. i, p. 538, indicates that inaccuracies have crept into the work: "From the earliest information we have of these nations" (the author is speaking of the New Mexicans), "they are known to have been tillers of the soil; and though the implements used and their methods of cultivation were both simple and primitive, cotton, corn, *wheat,* beans, and many varieties of fruits which constituted their principal food were raised in abundance."

Wheat was not grown on the American continent until after the landing of the first explorers.

[21] Gard. Chron., 1888.

[22] Pickled Daikon, the large radish, often grated.

Ginger-roots—Shoga.

Beans (*Glycine hispida*), many kinds, and prepared in many ways.

Beans (*Dolichos cultratus*), cooked in rice and mixed with it.

Sliced Hasu, Lotos roots.

Lily bulbs, boiled whole and the scales torn off as they are eaten.

Pickled green plums, (Ume-boshi) colored red in the pickle, by the leaves of *Perilla arguta* (Shiso).

Sliced and dried cucumbers, Kiuri.

Pieces of Gobo,—Roots of *Lappa major.*

Rakkio.—Bulbs of *Allium Bakeri*, boiled in Shogu.
Grated Wasabi.—Stem of *Eutrema Wasabi*.
Water-cress.—Midzu-tagarashi (not often).
Also sometimes pickled greens of various kinds, and occasionally chestnut-kernels boiled and mixed with a kind of sweet sauce.
Nut of the Ginkgo tree.
Several kinds of seaweeds are also very commonly served with the rice. Professor C. C. Georgeson in letter.

[23] l. c. Preface in English Edition.

[24] "Carbonized apples have been found at Wangen, sometimes whole, sometimes cut in two, or, more rarely, into four pieces and evidently dried and put aside for winter use. . . . . They are small and generally resemble those which still grow wild in the Swiss forests; at Robenhausen, however, specimens have occurred which are of larger size, and probably cultivated. No trace of the vine, the walnut, the cherry, or the damson has yet been met with, but stones of the wild plum and the *Prunus padus* have been found." LUBBOCK, *l. c.*, p. 217.

[25] *Animals and Plants under Domestication* (Am. Edn.), vol. ii, p. 205–209.

[26] *American Garden*, N. Y. 1890–91.

[27] *American Garden*, N. Y. 1891.

[28] *Useful Native Plants of Australia*, by J. H. MAIDEN, Sydney.

[29] *The Flowers of Japan* and the Art of Floral Arrangement. By JOSIAH CONDER, F.R.I.B.A., Architect to the Imperial Japanese Government. Yokohama, 1891. See also two other works by the same author: Theory of Japanese Flower-arrangements, and Art of Landscape-gardening in Japan. (1886.)

[30] Mr. SAMUEL DIXON'S list is in vol. viii (for 1884–85) of the *Transactions and Proceedings and Report of the Royal Society of South Australia*. Adelaide, G. Robertson, 1886.

Bursaria spinosa, "a good stand-by," after the grasses dry up.
Pomaderris racemosa, "stands stocking well."
Pittosporum phyllaeroides, "sheep exceedingly partial to its foliage."
Casuarina quadrivalvis, "tenderness of fiber, wool would be represented by it in our finer wool districts."
Acacias, The Wattles. "Value as an astringent, very great," being curative of a malady often caused by eating frozen grass.
Acacia aneura (mulga). "Must be very nutritious to all animals eating it." This is the plant which is such a terror to the stockmen who have to ride through the "scrub."
Cassia, some of the species with good pods and leaves for sheep.
The foregoing are found in districts which are not wholly arid.
The following are, more properly, "dry" plants.
Sida petrophila, "as much liked by sheep as by marsupials."
Dodonaea viscosa, Native Hop-bush. "Likes warm, red, sandy ground."
Lycium australe, "Drought never seems to affect it."
Kochia aphylla: "All kinds of stock are often largely dependent on it during protracted droughts."
Rhagodia parabolica: "Produces a good deal of foliage."
Atriplex vesicaria: "Can be readily grown wherever the climate is not too wet."
I have transferred only those which Mr. Dixon thinks most worthy of trial. Compare also Dr. VASEY'S valuable studies of the plants of our dry lands, especially Grasses and Forage plants (1878), Grasses of the arid districts of Kansas, Nebraska, and Colorado (1886), Grasses of the South (1887.

[31] The weeds of German gardens and agricultural lands are mostly from Mediterranean regions, but the invasions in the uncultivated districts are chiefly from America, (such as *Oenothera*, *Mimulus*, *Rudbeckia*). Handbuch der *Pflanzengeographie*, von Dr. OSCAR DRUDE, (Stuttgart), 1890, p. 97.

[32] The list of economic plants published by the Department in Washington is remarkably full, and is in every way creditable to those in charge.

Art. XXVIII.—*On the Vitality of some Annual Plants;* by Theo. Holm. (With Plate X.)

The curious fact, that there may be individuals of annual species of which the life-time is not limited merely to one year, has been noticed by several botanists. Exceptions of that kind often seem to be nearly accidental, but in most cases they are, however, to be considered as due to certain external factors, as for instance climate and soil or cultivation. Indeed, the number is not very small of the species in which a fluctuation has been observed from being annual to perennial or at least biennial in a modified sense, as well as of those for which similar intergradation-forms have been recorded between the biennial on the one side and the annual and perennial ones on the other.

Irmisch* mentions for instance, that *Echinospermum Lappula*, which is usually biennial may occur as annual, having already developed the flowers in the first year; he observed that the same is true in the case of *Hyoscyamus niger*, of which even the annual form has been described as a proper species (*H. agrestis*) since it is very different in habit from the biennial type. The same author has also observed, that *Hypericum humifusum* and *Malva neglecta* may occur as both annual and perennial. *Sedum annuum*, which has been described as annual by Hartman, Areschoug and Blytt, was observed by Warming† to be biennial, and even that this seemed to be the normal for this plant.

Hildebrand‡ enumerates several species, which, although they occur under widely different conditions in both hemispheres, nevertheless seem to be constant as to their life-duration and habit; such species for example are the annual *Polygonum aviculare*, *Erigeron Canadensis*, *Papaver Rhœas*, etc., while of perennials *Thymus serpyllum*, *Verbena officinalis*, *Urtica dioica*, etc. He enumerates on the other hand several other species, which show a tendency to vary from annual to biennial, among which are many *Cruciferæ*, *Compositæ* and cultivated *Gramineæ*, besides some usually biennial species, which may occur as perennials, as for instance some *Cruciferæ*, *Umbelliferæ*, *Papilionaceæ*, etc. Similar aberrant forms are evidently far from rare in this country, though the author has not

* Thilo Irmisch: Zur Morphologie der monocot. Knollen und Zwiebelgewächse, 1850, p. 211.

† Eug. Warming: Om Skudbygning, Overvintring og Foryngelse. (Naturhist. Forenings Festskrift, 1884. p. 16.)

‡ Fr. Hildebrand: Die Lebensdauer und Vegetationsweise der Pflanzen, ihre Ursachen und ihre Entwickelung. (Engler's Botanische Jahrbücher, vol. ii, 1881, p. 51.)

succeeded in finding any special observations in the literature, and as he has had the opportunity of observing a few cases of that kind, they seem to likely to be of some interest, at least locally.

Hypericum nudicaule Walt. (*H. Sarothra* Michx.) is undoubtedly typically annual, but a few individuals were, however, collected late in the fall, which seemed to prove an exception. The base of one of these specimens is figured on plate X, fig. 1, and we see here two densely leaved branches proceeding from the lower part of the stem, and probably developed in the axils of the cotyledons. These shoots with numerous imbricate leaves might be supposed to be able to winter over and in the following year to give rise to flowers; the root-system in these individuals was unusually strong, showing not only a primary root, but also a few, and rather strong, lateral ones.

Another example is *Delphinium consolida* L., which as far as known to the author has not been recorded as otherwise than annual in Europe and here. The plant is rather rare in the vicinity of Washington, but occurs as escaped from cultivation on the banks of the Potomac. It was observed here to vary from annual to perennial, although both forms were growing together, and the perennial form showed a strong, persistent primary root and several flowering stems, besides a cluster of buds for the following year.

This kind of variation was also observed in *Cyperus flavescens* L., a plant, which is rather common in wet places around Washington, and I have sometimes met with individuals, which certainly seemed to be perennial. One of these is figured on plate X, fig. 6, and shows in contrast to the annual type a distinct rhizome with creeping stolons, from the nodes of which several strong roots proceed. It must be admitted that this specimen shows the general aspect of a perennial, stoloniferous *Cyperus*, able to give rise to new individuals by a vegetative propagation. Whether this species has been recorded as perennial also in other countries, I do not know, but Lange* mentions, however, the fact that he has collected the plant in France, where some specimens showed "tuberous stolons," and therefore questions its character as annual. Grenier and Godron† have, nevertheless, described the plant as merely annual. It might be mentioned here, that a similar variation also exists in *Carex cyperoides* L., which under normal conditions is truly annual; Lange states (l. c. p. 118) that the periodical disappearance of this plant in several parts of Europe has been explained by the fact, that it is able to veg-

* Joh. Lange: Haandbog i den danske Flora, 1886–88, p. 116.
† Grenier et Godron: Flore de France, vol. iii, 1855.

etate for several years without flowering, if the locality becomes inundated.*

It seems then, that this ability to vary among *Cyperaceæ* is easy to explain, although it may not be a necessary consequence in all cases; our specimens of *Cyperus* were observed as occurring together with numerous annual individuals and under the very same conditions.

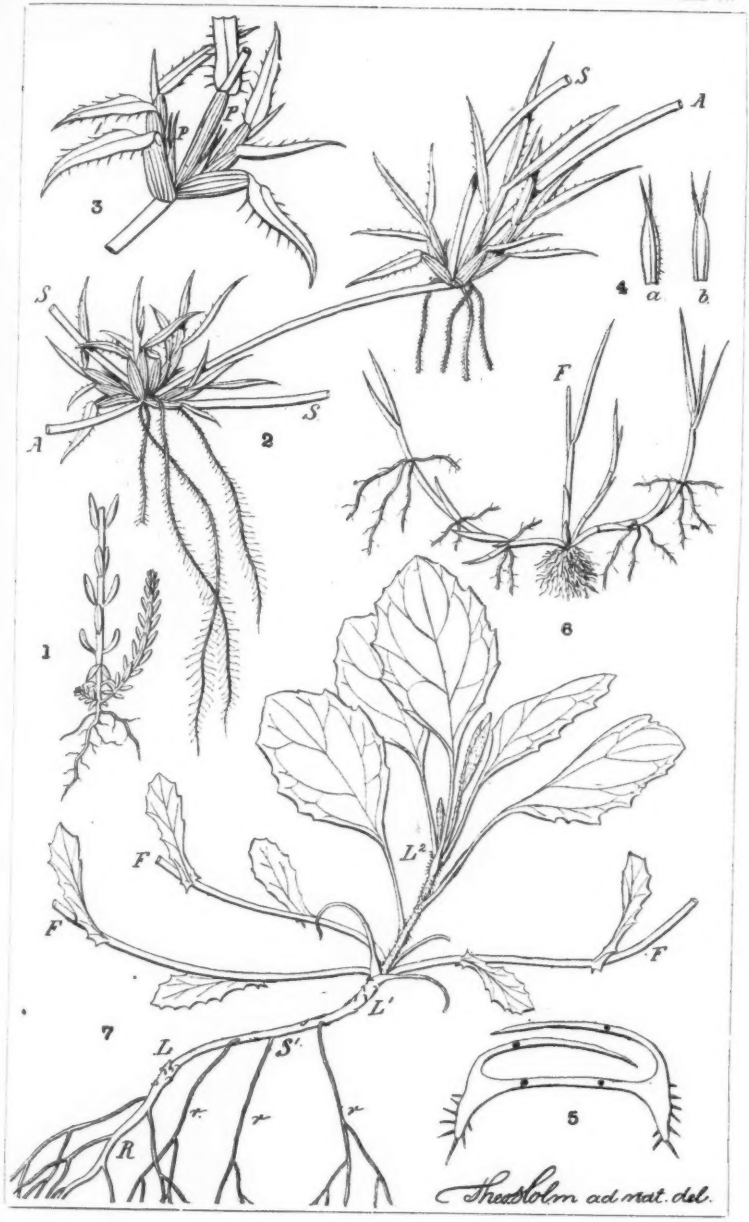
The *Gramineæ* may undoubtedly include several other species, besides the cultivated ones, mentioned by Hildebrand (l. c.) in which this same variation may take place. *Tragus racemosus* Hall, represents at least the same case as that of *Cyperus*. It has always been considered as annual, lately by Dr. Vasey,† although some specimens in U. S. National herbarium prove, that it can also occur as perennial. These specimens have long stolons above-ground with abundant formation of leafy shoots at each node, from where long roots are also developed. A part of a stolon has been illustrated in plate X, fig. 2, where we see not only the crowded shoots, but also a secondary formation stolons (S). All these shoots were developed in the axils of leaves, belonging to the stolons, and they showed besides the proper leaves also the characteristic prophyllum (fig. 3). This small leaf had a rather unusual shape than otherwise observed; it was not only distinctly bicarinate, but showed at its apex two long teeth, corresponding to those of an ordinary palet (fig. 4). A transverse section (fig. 5) of the prophyllum shows the prominent keels and the very thin margins, besides the presence of not only two, but even six nerves, those of the keels being the strongest.

This manner of growth seems to be rather common in North American *Graminæ*, especially those, which ramify, and there is no doubt that under favorable conditions they might change their habit from annual to perennial or at least biennial.

The *Cruciferæ*, which include representatives of all the three types of growth, are, as mentioned above, quite apt to vary in a similar manner. The genus *Arabis* is very instructive in this regard, as for instance *A. dentata* Torr. et Gr., of which the lower part of a perennial specimen has been figured on Plate X, fig. 7, which shows the character of a biennial in a perennial form. We see here a leafy shoot terminating the main axis, from the leaves of which flowering stems will be developed next year. We see further, that the base of this shoot is surrounded by now faded leaves, merely indicated by the petioles, and from the axils of which proceed the ascending flowering stems of the year.

* Compare: Bull. de la Société botan. de France, 1860, p. 186.

† Geo. Vasey: Grasses of the Southwest, Part I, 1890. (Bull. of U. S. Dept. of Agriculture).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Sheasholm ad nat. del.

The plant illustrates then at once the two stages of a biennial growth: the leafy roset, which will winter over, and the flowering stems from a similar roset of the preceding year. The age of this specimen is at least three years, for there is a distinct stem-part (S^1) to be seen between the primary root and the now faded roset of leaves. This part of the stem is in contrast to the upper part which is horizontal and fixed to the ground by strong roots in addition to the persistent primary one. The plant has undoubtedly merely developed a leafy roset in its first year, when the seed germinated, probably flowered the second year and produced the stem-part S^1, flowered again in the third year, producing contemporarily a shoot that will flower next year, until finally an inflorescence will terminate the main axis and the entire individual die away after the ripening of the fruits.

The closely allied *A. lyrata* L. has been mentioned by Hildebrand (l. c.) as being annual or biennial. It occurs, however, also as perennial, and most commonly so in the Southern United States. I have collected several specimens in the vicinity of Washington, which were all decidedly perennial, and most of the individuals in the National Herbarium from other parts of North America showed the same fact. Some specimens from Japan were, however, annual, with flowers and leaves developed in the first year and at the same time. The perennial form shows nearly the same habit as above described for *A. dentata*, but commonly with a profuse development of lateral leafy shoots together with the inflorescences, so that the life is secured for a considerably longer time than in the preceding species.

That also *Arabis lævigata* Poir. may occur as perennial has been recorded by Hildebrand (l. c.), but without data; Gray has considered this species as truly biennial, in which form it occurs exclusively around Washington, where it is very abundant.

Washington, D. C., July 22d, 1891.

EXPLANATION OF PLATE X.

FIG. 1.—*Hypericum nudicaule.* The base of the stem, showing two densely leaved shoots. Natural size.

FIG. 2.—*Tragus racemosus.* Part of a stolon A–A, with secondary branches S and several crowded shoots. Natural size.

FIG. 3.—Same. Part of a stolon, showing two leafy shoots in the axils of two leaves, belonging to the stolon. P, the prophyllum. Slightly enlarged.

FIG. 4.—Same. The prophyllum; *a*, side, and *b*, back view.

FIG. 5.—Same. Transverse section of the prophyllum.

FIG. 6.—*Cyperus flavescens.* The base of a perennial specimen, showing the stolons. F, the base of the flowering stem. Natural size.

FIG. 7.—*Arabis dentata.* The base of the plant, showing the primary root (R) and some secondary ones (*r*). L, L^1 and L^2 indicate the leafy rosets of 1st, 2d and 3d year. F, the lower part of flowering stems. Natural size.

ART. XXIX.—*A Method for the Separation of Antimony from Arsenic by the Simultaneous Action of Hydrochloric and Hydriodic Acids;* by F. A. GOOCH and E. W. DANNER.

[Contributions from the Kent Chemical Laboratory of Yale College—IX.]

A METHOD for the separation of arsenic from antimony based upon the difference in volatility of the lower chlorides was introduced originally by Fischer.* This method of treatment consisted in the reduction of the chlorides by means of ferrous chloride and the volatilization of the arsenic by repeated distillations of the mixture with hydrochloric acid of twenty per cent strength added in successive portions. The process has been subsequently modified by Hufschmidt† by the substitution of gaseous hydrochloric acid, introduced in continuous current into the distilling mixture, for the aqueous acid, and later changed further and improved by Classen and Ludwig,‡ who employ ferrous sulphate, or ammonio-ferrous sulphate, in place of the less easily prepared ferrous chloride. In its latest form the method is exceedingly exact, but the conditions are such that the antimony in the residue must be determined gravimetrically. It has been our endeavor to so arrange the process that the determination of the antimony may be made by a rapid volumetric method, and this we have attempted to accomplish by substituting for the iron salt, which utterly precludes the direct volumetric estimation of the antimony, another reducer—hydriodic acid—which can interfere in no way with the subsequent determination of the antimony by the well known iodometric method.

It has been shown in previous work in this laboratory that arsenic§ and antimony‖ may both be reduced by the action of hydriodic acid applied under appropriate conditions. In those processes, however, it was essential that the arsenic should not volatilize, and the conditions were adjusted accordingly. In the present case we have to test the reducing action of hydriodic acid in the presence of strong hydrochloric acid and at the boiling temperature of the solution—conditions arranged to bring about the volatilization of the arsenic as rapidly as possible. Certain preliminary experiments gave indication that a half gram of arsenic oxide could be completely volatilized by the action of potassium iodide in excess in the manner described, and that an equivalent weight of antimonious oxide

* Ann. Chem. u. Pharm. 208, 182. † Ber. d. deutsch. chem. Ges., xvii, 2245.
‡ Ber. d. deutsch. chem. Ges. xviii, 1110.
§ Gooch and Browning, this Journal. vol. xl, p. 66.
‖ Gooch and Gruener, this Journal, vol. xlii, p. 213.

(added in the form of tartar emetic) was retained entirely in the residue under similar conditions of treatment. Moreover, it appeared that this action could be brought about in solutions measuring no more than 100 cm.^{3} at the beginning and no less than 50 cm.^{3} at the end of the distillation, so that a very considerable saving of time over that demanded by the process of distillation as left by Classen and Ludwig could be effected. Accordingly we proceeded to test the action of the hydriodic acid quantitatively, following the same general lines. The distillation-apparatus consisted of a flask of 250 cm.^{3} capacity, provided with a hollow glass stopper tightly fitted in a ground joint, the stopper itself being sealed upon a large glass tube bent suitably to connect the interior of the flask with an upright condenser, while through the hollow stopper, and sealed into it, passed a smaller glass tube reaching nearly to the bottom of the flask. The arrangement was such that a current of gas entering the smaller tube would pass nearly to the bottom of the flask and then out through the hollow stopper into the condenser without meeting joints of rubber or cork. Into this flask was weighed, for the experiments of Table I, about a half gram of carefully recrystallized tartar emetic, and a half gram of pure di-hydrogen potassium arseniate and a gram of potassium iodide were added in concentrated solution, the volume of liquid being made up to 100 cm.^{3} by the addition of strong hydrochloric acid. A brisk current of hydrochloric acid gas was passed into the solution through the tube sealed into the glass stopper of the flask until complete saturation was effected, and then the liquid was heated and distilled in the continuous current of hydrochloric acid gas until the volume of 30 cm.^{3} was reached. Iodine was evolved as soon as the liquid became warm and the greater part of it passed into the distillate with the first 10 cm.^{3} When the final concentration was reached the solution was in each case colorless, but on cooling there appeared in one of the two experiments of this set a pale yellow tint which vanished with the dilution involved in the transfer and washing from the flask previous to titration. The addition of starch to the cooled and diluted liquid developed no color. To the liquid were added 1 grm. of tartaric acid, to keep the antimony in solution during subsequent treatment, sodium hydrate nearly to neutrality, and hydrogen sodium carbonate in excess amounting to about 20 cm.^{3} of the saturated solution; and the antimonious oxide in solution was titrated by decinormal iodine standardized against tartar emetic. The details of these experiments are given in Table I.

In Table II are comprised the accounts of experiments similar in general to those of Table I, excepting that the final

volume after concentration was a little more, and the antimony was in every case oxidized in alkaline solution by standard iodine previous to the introduction of hydrochloric acid and distillation.

Table III includes the records of experiments similar in every respect to those of Table II excepting that as starch showed a slight color in the cooled liquid after distillation, the solution was treated with an excess of sulphurous acid which was subsequently oxidized exactly by standard iodine previous to neutralization and the final titration.

I.

H_2KAsO_4 taken.	KI taken.	Volume initial.	Volume final.	Color on cooling.	Color with starch.	Sb_2O_3 taken.	Sb_2O_3 found.	Error.
grm.	grm.	cm.³	cm.³			grm.	grm.	grm.
0·5	1·0	100	30	pale yellow	none	0·2282	0·2271	0·0011—
0·5	1·0	100	30	none	none	0 2283	0 2266	0·0017—
				II.				
0·5	0·5	120	50	none	none	0·2258	0·2235	0·0023—
0·5	0·5	100	50	pale yellow	none	0·2252	0·2235	0·0017—
0·5	0·5	100	50	pale yellow	none	0·2178	0·2163	0·0015—
0·5	0·5	100	50	trace	none	0·2231	0·2231	0·0000
0·5	0·5	100	40	trace	none	0·2261	0·2235	0·0026—
				III.				
0·5	0·5	100	50	pale yellow	faint	0·2268	0 2265	0·0003—
0·5	0·5	100	50	pale yellow	faint	0·2306	0·2300	0·0006—
0·5	0·5	100	50	pale yellow	faint	0·2272	0·2264	0·0008—

The same general phenomena were observed in all these experiments, and deficiencies in the amounts of antimony indicated, whether the element was present in the lower or higher degree of oxidation before distillation, appear in all, but most notably in the results of Tables I and II. These losses cannot be attributed, entirely at least, to mechanical transfer in the process, inasmuch as the greater losses are not associated with the greater concentrations; and, furthermore, according to our qualitative experiments made under the conditions of these determinations, no antimony, so far as we could observe, passes into the distillate. If the coloration of the liquid on cooling were due to the liberation of iodine by the action of air upon the hydriodic acid the iodine thus set free might be counted upon to oxidize a corresponding portion of the antimony in the neutralization, and so to occasion a deficiency in the indications of titration. Against this supposition, however, we have the evidence of experiment that the greatest losses are not found in those cases in which color was developed in the cooling liquid. Moreover, in all cases,

excepting those of Table III, starch gave no test for free iodine in the diluted liquid, though it must not be overlooked that the presence of a considerable amount of hydrochloric acid tends to impair the delicacy of the test. If, on the other hand, the color is not due altogether to free iodine it is difficult to account for its development unless it is caused by the formation of antimonious iodide as the solution of strong hydrochloric containing also hydriodic acid cools. On the whole, we are inclined to attribute at least a part of the apparent deficiency to the presence, at the time of neutralization, of a small amount of iodine chloride, which, in accordance with what is known of its modes of formation, might be formed by the oxidizing effect of the antimonic and arsenic oxides upon the mixed acids. At all events, it is evident that if iodine chloride were present we should expect to note the phenomena which we do see; it would give, in small quantity, little or no color to the liquid, would not show the starch reaction for free iodine in the acid solution, and would be destroyed with the formation hydrochloric and hydriodic acids by the addition of sulphurous acid to the still acid liquid, leaving the antimony unchanged and determinable iodometrically in alkaline solution after the exact oxidation of the excess of sulphurous acid by iodine in acid solution; on the other hand, it would act in alkaline solution like the free halogens and tend to diminish the antimony indicated by titration. Whatever the real cause or causes of the deficiency may be, it appears in the results of Table III that the treatment with sulphurous acid affects the indications favorably. The mean error of three closely agreeing determinations is 0·0006 grm.—and this is plainly within the limits of allowable variation in iodometric work with decinormal solutions.

It appears, therefore, that hydriodic acid may be made to serve satisfactorily as a substitute for the ferrous chloride of Fischer's original method, or for the ferrous sulphate of the modification of Classen and Ludwig, the determination of the residual antimony being perfectly practicable. The method of proceeding which we advocate is briefly summarized in the following statement: To the solution of the oxides of arsenic and antimony, taken in amounts not exceeding 0·5 grm. of each, potassium iodide is to be added in a little more than the equivalent quantity, and enough strong hydrochloric acid to raise the entire volume of the solution to 100 cm.^{3} Hydrochloric acid gas is passed into the liquid to saturation as well as during the distillation to follow, and the distillation is carried on until the volume of the liquid decreases to 50 cm.^{3} or a little less. The liquid is cooled rapidly, treated first with an excess of sulphurous acid and then with iodine to the exact

oxidation of the former reagent; and, after the addition of 1 grm. of tartaric acid to every 0·2 grm. of antimonious oxide, the acid present is nearly neutralized with sodium hydrate, the neutralization being completed by hydrogen sodium carbonate added in excess to an amount corresponding to 10 cm.³ of the saturated solution for every 0·1 grm. of antimonious oxide present. Titration with decinormal iodine standardized against tartar emetic gives the antimony quickly and with a fair degree of accuracy. The whole process requires about an hour and a half for completion.

ART. XXX.—*Notes on Allotropic Silver;* by M. CAREY LEA.

Relations of the Yellow to the Blue Forms.—The gold-and copper-colored forms on the one hand, and the blue, bluish-green and steel-gray on the other hand stand in close relations to each other. In previous papers there has been described a crystalline state intermediate between these active forms and ordinary silver, which intermediate condition, while retaining the bright yellow color of the active form is nearly as indifferent to reagents as ordinary silver. Into this intermediate state both the yellow and blue forms are capable of passing, and apparently the intermediate states of both kinds of allotropic silver are identical: *the intermediate form of blue silver is yellow.* Thus when lumps of blue silver are heated in a test tube to about 180° C. they assume a gold color and luster. The same change takes place at the same temperature when films of blue silver are placed in a hot air bath.

But relations much closer than these exist. Blue silver can be converted into yellow at ordinary temperatures and consequently with retention of its active properties. This is accomplished through the agency of sulphuric acid. When a solution of silver is obtained by the action of sodium hydroxide and dextrine on silver nitrate* it appears to contain the blue variety, for if allowed to precipitate spontaneously by long standing, or if precipitated by acetic acid, dilute nitric acid, or by many neutral substances, it gives a form of silver which is dark red while moist and dries with a blue surface

* Forty grams each of sodium hydroxide and of yellow or brown dextrine (not white) are dissolved in two litres of water and 28 grams of silver nitrate in solution are added in small quantities at a time, with frequent stirring, so that several hours shall elapse before the last portion is added. The solution is always slightly turbid when viewed by reflected light, by which it shows a beautiful deep green color. By transmitted light it is deep red, and when diluted, absolutely transparent. By diminishing the proportion of silver nitrate to one-half, a solution nearly or quite clear by reflected as well as by transmitted light is obtained.

color. (It is always a little difficult to characterize these substances by their colors since the surface color which they show when dry—either in mass or in films—is mostly complementary to their color when wet. As the surface color is much the more characteristic, I have adopted the course of naming them by that.)

The behavior of the red solution obtained by soda and dextrine with dilute sulphuric is very interesting and instructive. When 100 c.c. of solution are poured into 100 c.c. of water to which 3 c.c. of sulphuric acid have been previously added, a dark red precipitate falls, which, when dry, especially in films, is blue. The mixed liquid from which the precipitate is formed is acid. Increasing the proportion of acid to 4, 5 and 6 c.c. successively, the substance obtained has a green surface color becoming more yellowish green in proportion as the acid is increased in quantity. With 7½ c.c. the substance no longer dries green but yellow. Increased proportions of acid produce substances drying with a coppery shade.

It will be seen that from a single solution, and using one substance only as a precipitant, we can obtain the whole range of different forms of allotropic silver, by simply varying the proportions of the precipitant.

That these forms of silver should subsist in the presence of sulphuric acid in excess is remarkable. For the most part the presence of this acid tends to quickly convert allotropic to ordinary silver. For example, bright yellow allotropic silver obtained with ferrous tartrate was washed on a filter with water containing 1/500 its volume of sulphuric acid: in two or three hours the entire mass was converted into gray ordinary silver.

It is observable that the substances precipitated with the least acid, have a very splendid luster, and that this luster diminishes steadily as the proportion of acid is increased. Up to 6 c.c. to 100 the effect is hardly noticeable, after that it becomes more marked.

But we can also obtain the converse of this reaction. Just as the solution which naturally would yield the blue product, can be made to yield the yellow by the presence of excess of strong acid, so the solution which normally yields the yellow substance, may be made to produce blue (or rather green) silver by adding alkali. Thus a mixture of dilute solutions of ferrous sulphate and of Rochelle salt added to mixed solutions of silver nitrate and of Rochelle salt, results in the formation of gold-colored silver. But if we add a little sodium hydroxide, either to the iron solution or the silver mixture, we shall get a bluish green product, whose properties show that it belongs to the blue class and not to the yellow. Even if a

solution of the hydroxide is added immediately after the iron solution has been poured into the silver, the result is the same.

There is therefore a well marked tendency of acids to give rise to the formation of the yellow product and of alkalies to the blue. But this is a tendency only. Both substances can be produced from neutral solutions, and slight changes are sufficient to alter the product formed. Thus, ferrous tartrate, in dilute solution acting on silver tartrate gives rise to the formation of the gold-colored substance, but when citrates are substituted, the blue substance is obtained.

Production of Allotropic Silver by Inorganic Substances.—For reasons which will be mentioned presently, the reduction of silver must take place gradually to produce the allotropic form, and for a time it seemed an invariable condition that an organic substance of some sort should be present. This, however, proves not to be essential. In a paper presented to the American Academy and kindly read for me by Professor Remsen at the meeting in April last, I alluded briefly to having found a reaction depending upon inorganic agents only. It is as follows: Sodium hypophosphite added to silver nitrate does not effect reduction, but when hypophosphorous acid is set free by the addition of phosphoric acid, a red coloration appears, indicating the presence of allotropic silver. The coloration is transitory, no doubt because of the strong tendency of free mineral acids to convert allotropic to normal silver, but red and blue stains form on the sides of the vessel.

Phosphorous acid gives similar results, though perhaps less well marked.

Action of Light on Blue Silver.—This action differs with different varieties: it was more especially examined with the form that is obtained from the soda dextrine silver solution already described by pouring the solution into an equal bulk of water to which sulphuric acid had been added in the proportion of 4 c.c. to each 100 c.c. of water. This form was selected because it is easy to obtain with great constancy of result, and because it is one of the forms of blue silver most sensitive to light.

Exposed to light, this substance first becomes more distinctly blue, losing a slight greenish shade. With continued exposure it passes to a yellow-brown shade, and finally to a perfectly pure golden-yellow of great brilliancy and luster. The last is the intermediate or crystalline form.

The action of light on this form of silver is remarkable in this respect, that its first effect is to *increase* the sensitiveness to reagents.

This result was so unexpected and *a priori* so improbable, that it was subjected to the most careful verification before

being accepted. The action is very easily shown by exposing a film of the substance to light, covering part of the surface with an opaque screen. After twenty or thirty minutes of exposure to strong summer sunshine, the film may be plunged into a one per cent solution of potassium ferridcyanide, when the part exposed colors much sooner and more strongly than that which was covered. The effect is shown still better by placing the film in a frame, covering part with paper rendered absolutely opaque by coating it with thick tin foil, part with translucent paper (thick white writing paper or very thin brown paper) and leaving part wholly exposed. After four or five hours action of strong summer sunshine, the film is to be treated with weak ferridcyanide. The part wholly exposed having passed into the gold-colored crystalline condition (if the exposure has been sufficient) is wholly unacted upon, the part covered by the translucent paper is rapidly attacked, that wholly protected is attacked slowly. So that the portion moderately acted on by light has very markedly increased in sensitiveness thereby.

It follows that upon this form of silver *light has a reversing action*, first exalting its sensitiveness, then completely destroying it.

It is impossible to overlook the analogy which exists between this action of light, and that which light exerts on silver bromide.

The latter substance though incomparably more sensitive to light, is subject to the same reversing action, first gaining in sensitiveness to reducing agents and then, by continued exposure, becoming less sensitive than originally, a change commonly known as solarization.

Causes determining whether in the reduction of Silver, the Allotropic or the Normal form shall be produced.—I have examined the phenomena connected with the reduction of silver under a great variety of conditions. These for the most part do not deserve particular mention but seem to lead up to this generalization: that the reduction of silver may be direct or indirect, direct when it passes from the condition of the normal salt or oxide to that of the metal, indirect when the change is first to sub-oxide or to a corresponding sub-salt. So far as my observation has gone when the reduction is *direct* the reduced silver always appears in its ordinary form. But when the reduction is *indirect* the silver presents itself in one of its allotropic states.

The following reactions support this view.

Three of the principal modes of formation of allotropic silver are: (1) reduction of silver citrate or tartrate by ferrous citrate or tartrate; (2) acting on silver nitrate or oxide by

dextrine and fixed alkaline hydroxide; (3) acting on silver nitrate or carbonate by tannin and fixed alkaline carbonate. Now, if in either of these three cases we interrupt the action before it is complete by adding an excess of dilute hydrochloric acid we shall obtain a dark chestnut-brown or sometimes purple-brown substance which on examination proves to be a mixture of silver subchloride and photochloride. When, after complete removal of the excess of hydrochloric acid by thorough washing or better by boiling with distilled water, the substance is treated with cold dilute nitric acid that portion of the sub-chloride which is not combined with the normal chloride is broken up and there remains photochloride of a very rich and intense rose-color.*

The production of silver sub-chloride in all these cases would seem to indicate that the reduction when the acid was added was incomplete, and that in case (1) a sub-salt, and in cases (2) and (3) a sub-oxide was first formed as an intermediate step before complete reduction. Either of these substances would of course give rise to the formation of subchloride when treated with hydrochloric acid. It is important to observe that this result is to be obtained only by interrupting the reaction before it is complete. When, for example, allotropic silver in solution is produced by the action of sodic hydroxide and dextrine and after complete reduction, hydrochloric acid is added, the liquid becomes filled with gray normal silver, which presently collects to a cake. When this cake is well washed and boiled with water, and then treated with dilute nitric acid, solution takes place: a trace of photochloride is left behind. It has been mentioned elsewhere that hydrochloric acid, though without action on ordinary silver, is capable of forming a variable quantity of protochloride when placed in contact with allotropic silver.

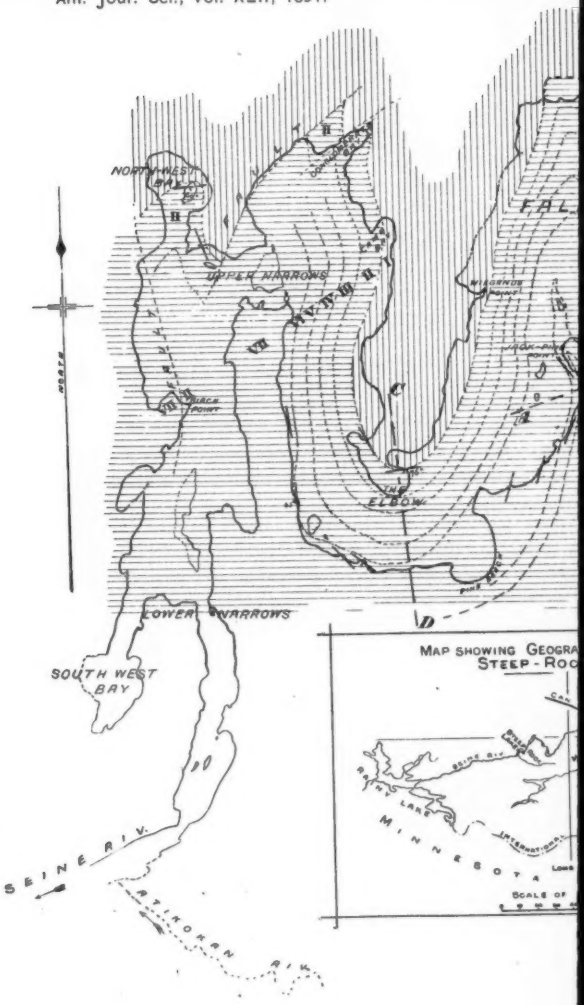
I have not met with any exception to this general principle that when a reaction leading to the formation of allotropic silver is interrupted by the addition of hydrochloric acid, subchloride is abundantly formed as one of the products.

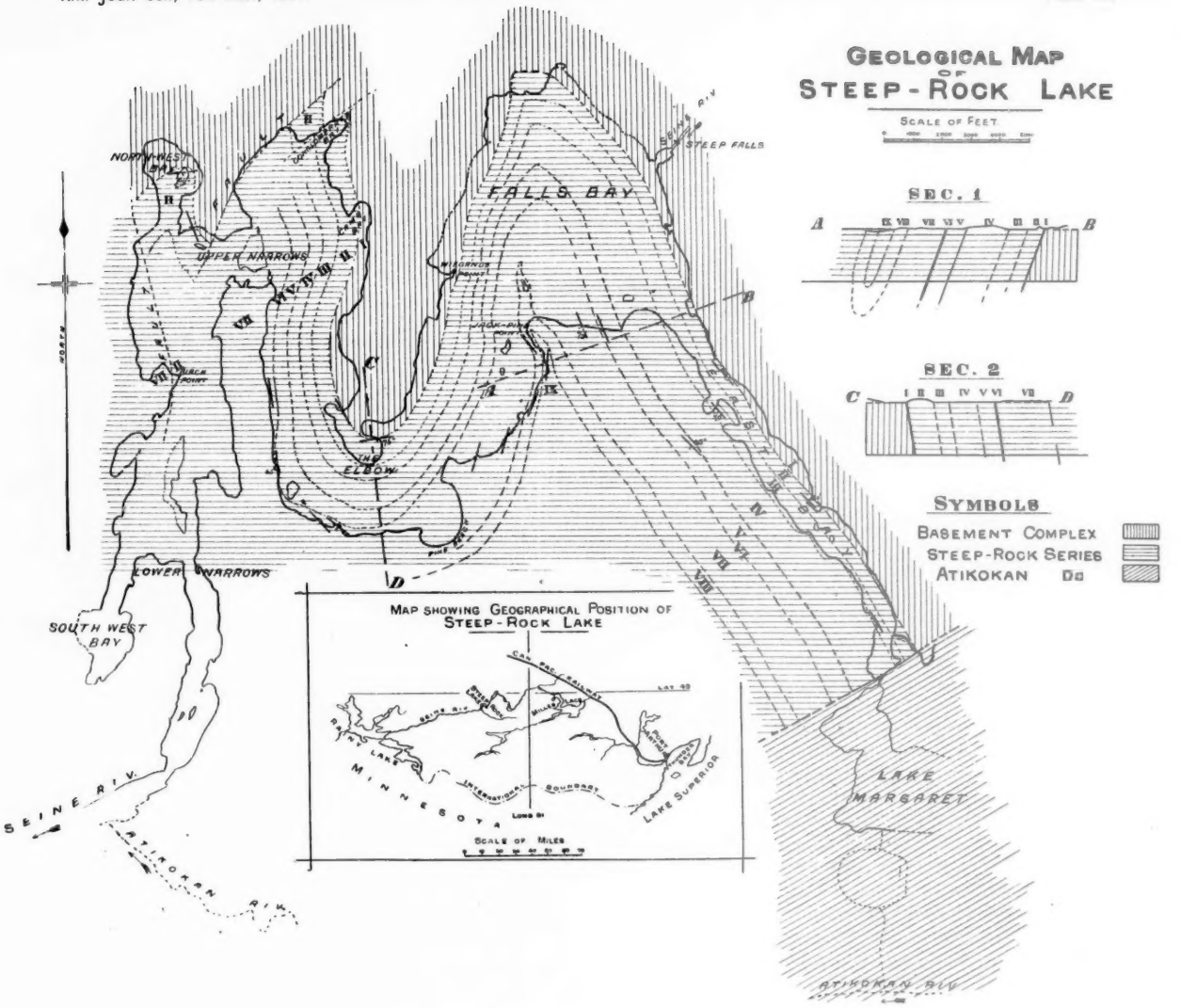
In all such cases the reduction is evidently indirect. The silver does not lose at once the whole of its oxygen, but apparently passes through an intermediate form, probably Ag_4O, the reduction of which tends to the formation of allotropic silver.

These facts lead directly up to the question: does silver exist in its subsalts in the allotropic form? There are some

* This is a very beautiful reaction and deserves more particular mention than can be given here. It is perhaps the best means for obtaining silver photochloride, for which purpose I have often employed it, both on account of its facility and certainty, and the very beautiful color of the product.

Am. Jour. Sci., Vol. XLII, 1891.




GEOLOGICAL MAP
OF
STEEP-ROCK LAKE
SCALE OF FEET
SEC. 1
SEC. 2
SYMBOLS
BASEMENT COMPLEX
STEEP-ROCK SERIES
ATIKOKAN
FALLS BAY
NORTH WEST BAY
UPPER NARROWS
LOWER NARROWS
SOUTH WEST BAY
THE ELBOW
SEINE R.
STEEP FALLS
LAKE MARGARET
ATIKOKAN R.
MAP SHOWING GEOGRAPHICAL POSITION OF STEEP-ROCK LAKE
MINNESOTA
LAKE SUPERIOR
SCALE OF MILES

facts that would support this view, especially the very rich and varied coloration of the subsalts corresponding to the almost infinite variety of color of allotropic silver, while normal salts of silver when formed with colorless acids are mostly colorless. On the other hand, the greater activity of allotropic silver and its less specific gravity would seem to indicate a simpler molecular constitution than that of normal silver.

ART. XXXI.—*Structural Geology of Steep Rock Lake, Ontario;* by HENRY LLOYD SMYTH. With Plate XI.

GEOGRAPHY.

STEEP ROCK LAKE is situated in the Province of Ontario, Canada, northwest of Lake Superior and south of the Canadian Pacific Railway. It lies about twenty-five miles east of the center of the rough quadrilateral formed by the Canadian Pacific Railway on the northeast, the Lake of the Woods on the northwest, the United States boundary on the southwest, and the shore of Lake Superior from Pigeon River to Port Arthur, on the southeast. As given on the map of the Province, scale 1 inch = 30 miles, published by the Crown Lands Department, Toronto, 1884, the geographical position of the extreme southern point of the lake, where it receives the waters of the Aticokan River from the east, is about lat. 48° 52′ N. and long. 91° 30′ W. from Greenwich; or, it is about halfway upon the map between Lac des Milles Lacs and Rainy Lake.

TOPOGRAPHY.

Steep Rock Lake is one of the many that, collectively, connected by longer or shorter links of river make up the River Seine from Island Falls as far as, and doubtless below, the Aticokan River. In shape the lake resembles, as shown on the map, an irregular and slightly distorted letter M, of which the western or left arm, (looking north), runs north and south, and the eastern or right arm northwest and southeast. This peculiar form is closely related to the character and to the structure of the rocks in which the lake lies as will be seen in what follows. The Seine River, after a beautiful fall, two hundred feet across, and forty to fifty feet high, over granite, some three hundred yards northeast of the lake, flows into it at a point about a mile southeast of the northwest extremity of the eastern arm. It leaves the lake at the extreme southern end of the western arm. Between the points of entrance and

exit there is no current observable by the eye and the difference in level must be exceedingly small.

As regards dimensions:—from the southern extremity of the eastern arm to the mouth of the river near the Falls is about 3½ miles; from the Falls to the Elbow, 3 miles; from the Elbow to the Upper Narrows, 1½ miles; and from the Upper Narrows south to the Aticokan River 3½ miles. The entire lake including the portion of Lake Margaret shown on the map could be inscribed within a rectangle 6 miles from east to west, and 5½ miles from north to south, or within an area of 33 square miles. As the name implies the lake has bold rocky shores, which, in places rise 150 feet from the water in nearly perpendicular cliffs. The total length of shore line is approximately 28 miles not counting the smaller bays and indentations. Not less than ¾ of this length shows rock in place either at the water's edge or within a few hundred feet of it, and of this perhaps ¼ may be studied without leaving the boat.

The contour of the water line shows a very beautiful dependence upon structural conditions. The eastern arm follows the general strike of the rocks from the bay north of Lake Margaret portage northwest to Falls Bay. On the northeastern shore of this arm the lower limestone makes several bold headlands that rise abruptly from 60 to 100 feet above the water. In the bays between these headlands the basement granites intersected by a large number of greenstone dikes form the shore, and rise more gently into the broken hummocky hills that generally characterize the granitic areas of the region. A few hundred feet back from the southwestern shore the great trap intrusions or flows of Horizon IV make a continuous ridge, which is estimated to reach a height of 250 feet above the water. This ridge runs, without interruption, the top showing only a few minor sags, from the shore west of the portage into Lake Margaret, for 3 miles along the strike in a northwest direction as far as the wide expansion of Falls Bay.

The gneissic phases of the granites, and associated irruptives compose the west shore of Falls Bay, from the great limestone exposure at the head, south to the Elbow. As far south as Wiegand's Point, the granite cliffs are high and very steep and are broken across only in two or three places. On the south shore of Falls Bay from Trap Point to Jack Pine Pt. the shore line cuts the strike of the rocks nearly at right angles, and from Jack Pine Pt. south to Pine Beach obliquely at a less angle. The ridges descend rather gradually to the lake along this shore, the harder rocks making little headlands separated by sand and shingle beaches.

From the southern point of Pine Beach the shore again follows the strike of the rocks, as it sweeps round the south pitching axis of the middle anticlinal; and in the stretch from Bowlder Point to the Upper Narrows, in which the strike locally varies between N. 2° W. and N. 18° E. the water line minutely corresponds to the minor deflections. This shore shows continuous rock exposure, and the cliffs reach a height in places of 40 or 50 feet above the water, having perpendicular faces along cleavage surfaces.

The highest land about the lake is north and west of Conglomerate Bay, and in the peninsula between it and Northwest Bay. Except for a fringe of the Conglomerate and lower limestone (Formations I and II) along Northwest Bay, and of the upper horizons of the series east of the fault line that crosses the southeast extremity, the peninsula is composed entirely of the basement gneisses and granites, which rise from the water west of Conglomerate Bay in a steep cliff (along a surface of faulting) 100 feet or more high. The hills in the northern part of the peninsula may reach a height of over 300 feet, but this as well as other figures concerning elevations is an eye-estimate only, and not a measurement.

Geology.

The rocks exposed around the shores of Steep Rock Lake and of Lake Margaret, are divisible into three principal groups. The lower division consists of granites and gneisses, which typically are medium grained, hornblendic, and granitoid, with faint foliation. Locally they present considerable variations in composition and very great variations in structure.

Resting upon these basement rocks is a series of rocks showing a thickness of about 5000 feet in exposure along the shores of the lake. Upper members that are not seen upon the lake probably exist in the trough of the eastern synclinal, southeast of Jack Pine Pt. The series is divisable into nine formation which as far as known are perfectly persistent along the strike throughout the area studied. It offers many important points of difference, lithologically, in structure, and in its relations to the underlying granites, from any series of rocks previously described in western Ontario. Leaving the question of correlation to be discussed after the series has been described it will be called for purposes of description in this paper, the Steep Rock Series.

At the southeastern extremity of the eastern arm, at the north end of the portage into Lake Margaret, lying across the edges of the Steep Rock Series, begins a succession of later granite porphyries, and massive hornblende rocks, striking

N. 55 to 65 E., which pass upward, in going south across the strike, into the schists of the Aticokan River. These will be termed the Aticokan Series.

Basement Complex.—The granites were very hastily examined in the narrow fringe in which they are exposed along certain shores of the lake. They were studied mainly with reference to their distribution and structural relations to the overlying Steep Rock series; no attempt can now be made to separate geographically the various kinds of rocks which are included in the basement series, or to indicate their relations to one another.

The predominant rock in the basement series is a hornblende muscovite granite of medium grain, composed of clear to bluish quartz, feldspar, a green hornblendic mineral, and muscovite. The color on the weathered surface is white, slightly tinged with green, and on the fresh fracture a darker well marked green. This is the usual type. Occasionally a red granite carrying biotite is seen, which owes its color to flesh-colored feldspar. True gneisses are rare, but they are occasionally found as at locality 50 on the ridge north of the mouth of the creek emptying into the bay north of Lake Margaret portage, and in the peninsula east of Northwest Bay, at locality 125. At both localities the rock is a coarse hornblende gneiss, exhibiting a parallel arrangement of the constitutent minerals, and pegmatization. At locality 125 the coarse gneiss carries angular inclusions, which are finer grained and darker than the mass of the rock, but similar in composition.

Distinguishable from these gneisses in which the origin of the gneissic foliation is unknown is a great body of chloritic gneisses which have unquestionably been derived from the hornblende granite by crushing. These are found at and near the turn of folds; for example, at the head of Falls Bay, north of the Elbow, and along the north and west shores of Northwest Bay. Good examples are seen on the west shore from the head of Falls Bay to the Elbow where the whole series has been forced round through an angle of more than 120°. All stages in the process are seen. At one end of the series is found the typical hornblende granite, traversed by little wavy fissures, generally parallel to the regional direction of cleavage, N. 43° E., along which part of the hornblende is represented by thin leaves of fresh chlorite. At the other end of the series the quartz and feldspar are greatly granulated, and the hornblende has entirely disappeared; the chlorite is arranged in parallel bands, and the rock has developed in it a highly perfect schistose structure.

All these granitic rocks are traversed by an immense number of dikes of greenstone, and more rarely of quartz porphyry, all of which for structural reasons are conveniently considered with the basement complex.

These belong to three eras of irruption. (1) Those which supplied pebbles to the conglomerate at the base of the Steep Rock series. (2) Those which are seen to traverse both the granitic and Steep Rock series, and to have participated in the folding. (3) A single massive dike of porphyrite (?), which cuts through the most schistose phase of the granite at the turn of the sharp fold at the head of N.W. Bay, and is clearly subsequent to the latest period of folding of the region. The dikes of class 2 are best seen along the N.E. shore of East Bay. They are rudely parallel, the walls are straight and nearly vertical, trending from N. 45° to N. 65° E., and in a general way cutting the granites and the lower horizons of the S. R. series in a direction normal to the contact and strike. They vary in width from one to two feet up to 70 feet, and clearly were the chimneys through which passed up the material for the great mass of interbedded traps on the south side of the same arm.

The contact phenomena with the country rock are uniformly as follows: When the dike is less than 6 or 8 feet in width it is fine grained, without crystalline structure, and throughout is highly schistose in the general regional direction. The wider dikes have massive and crystalline interiors, but are fine grained and schistose in a direction parallel to the induced regional cleavage, for a distance of 2½ or 3 feet from the wall. The country rock also is schistose next to the wall of the dike, the belt affected being narrower where the adjacent rock is granite than where it is limestone.

With regard to distribution, it may be said in a general way that all shore lines north of the water, from Lake Margaret to Northwest Bay, are, with few exceptions, made up of the rocks of the basement complex. The exceptions are the headlands in East Bay and at the Elbow which are of limestone, the great mass of limestone at the head of Falls Bay, and the limestone between Camp Bay and Conglomerate Bay, and the Conglomerate along the latter.

Steep Rock Series. — The Steep Rock series consist of 9 well marked and persistent horizons exposed about the lake. It is very probable that other higher members exist in the land area southeast of the shore from Jack Pine Pt. to Pine Beach. The 9 formations are given in the table below which reads upward in ascending order:

IX. Dark Gray clay slate.
VIII. Agglomerate.
VII. Greenstones and greenstone schists.
VI. Upper conglomerate.
V. Upper calcareous green schist.
IV. Interbedded crystalline traps.
III. Ferruginous formation.
II. Lower limestone.
I. Conglomerate.

In the foregoing description of the basement complex the northern limit of the Steep Rock series has roughly been indicated. Formations I and II occur in isolated patches north of the water on shores that are otherwise occupied only by the granites. Along the whole course of the lake they dip, at very steep angles, ranging from 60° to 80° away from the basement rocks, upon which they hang as a time-worn fringe, having no extension inland. The shore line lies sometimes in the granites and sometimes in the Steep Rock series, but in a general way follows closely in direction the boundary between them. It is only along these northern shores that formations I and II are seen at all, and as they are usually found together, separated from the higher members by intervening water, it will be convenient to keep them apart from the rest for purposes of description. The basal member of the Steep Rock series, which is generally found between the granites and the lower limestone, is a bed having a maximum thickness of nearly 100 feet, presenting the various phases of a conglomerate, coarse and fine, a quartzite and a quartz schist with feldspar. The formation occurs as a coarse conglomerate at the eastern end of Conglomerate Bay. The lowest member exposed at the water consists of rounded and water-worn pebbles of quartz and greenstone, of considerable size, the largest seen being a foot in diameter, imbedded in a green schistose matrix. The strike of the rock is about N. and S., as indicated both by the alignment of the pebbles, and the lines of junction of layers carrying no pebbles. No granitic pebbles were found at this locality. In the higher portion of the bed pebbles become smaller and relatively fewer, and the rock passes into a green schist, with small clastic grains of quartz.

On the northern end of the island in Northwest Bay formation (I) is represented by a fine conglomerate consisting of closely-packed small quartz grains (128) with little cementing material, holding occasional pebbles up to 3 or 4 inches in diameter, of rounded and water-worn quartz, bluish, milky-white and dark. A layer of limestone of uncertain thickness is also interbedded. The lowest formation does not usually occur as a coarse conglomerate in East Bay. It there consists,

as a rule, of beds of quartz pebbles, none larger than buckshot, with little cement, alternating with layers of massive quartzite.

In crossing from the base of the limestone to the granite it becomes at first slightly and then more and more feldspathic as the latter is approached. Near the junction both rocks are very similar in composition, so that it is quite impossible to draw the line between them from considerations of composition. There is an apparent transition from one rock into the other. This transition zone, which is from 20 to 30 feet in width, is uniformly highly schistose, in the regional direction N. 43° E., which, in the eastern arm, where the strikes are from N. 50° to 60° W., crosses the courses of the contact and the bedding nearly at right angles. The schistose structure is traceable through the transition zone into the undoubted granite in which it dies out gradually, being represented a few feet away by little discontinuous wavy cracks, along which chlorite is usually developed, and by a faint foliation.

From these facts it appears certain that the granitic complex supplied by erosion the materials for Formation I, and that the contact is therefore one of unconformability. There is no unconformability of structure; for the only normal structure possessed by the basement rocks, that of schistosity, was demonstrably imposed upon them at a time long subsequent to the accumulation of the various materials which now compose the Steep Rock series. The absence of a sharp line of demarkation between the complex and Formation I, which may seem to be a difficulty in the way of accepting the existence of an unconformability, is believed to be capable of a satisfactory explanation. In considering the orotechnic history of the region the transition zone will be shown to represent, not a transition in time, but a mechanical transition in composition, dating from a time subsequent to the accumulation of the rocks of the Steep Rock series.

Formation II, the lower limestone, lies above Formation I, with which it is seen in direct contact at a number of localities. The rock is very uniform in character wherever exposed. It is a dark to light bluish gray limestone, not at all highly crystalline, often banded with layers of lighter color, along planes of original bedding. The light bands vary in width from a fine line up to 6 or 8 inches. Bedding planes are also often marked by thin cherty seams. Basal portions are frequently massive and siliceous, and in some localities are highly charged with pyrites the decomposition of which causes the rock to weather brown. The upper part of the formation is a breccia, composed of fragments of limestone, showing original structure, and of trap, imbedded in a matrix that seems to be mostly made up of a consolidated calcareous flour. It is widely

distributed, and is nearly if not quite coextensive with the limestone. The total thickness of the lower limestone cannot be determined precisely, as it is nowhere seen in contact with the overlying Formation III, but quite surely is not less than 500 nor more than 700 feet. A much greater thickness is exposed in the north side of Conglomerate Bay, in part resulting from duplication by faulting. On the eastern arm, where the rocks are comparatively undisturbed the limits indicated are those given above.

Formation III is found only on the south shore of the eastern arm which it fringes from the Point N.W. of Lake Margaret Portage to Falls Bay, in much the same way that the limestone fringes the north shore. As a whole the formation consists of an extremely soft, fissile dull green, very pyritiferous rock, which carries in some localities many pebbles of limestone and a few of trap. In the lower parts of the formation the limestone fragments, which are identical with the rock of Formation II, are rather numerous, and some are large, one, angular in shape, being over two feet in diameter. Others are apparently rounded and waterworn. In other localities pebbles are not found at all. For the most part the only structure observable is the regional cleavage which is very perfectly developed. At two localities a fine banding parallel to the strike of the rock was observed. At loc. 27, south of trap bluff this banding is very prettily shown. The rock carries a few rounded pebbles of limestone. The banded structure is thrown into little compressed S.W. pitching folds the tangent plane to which is parallel to the plane of the dip in the limestone across the bay. Apart from the limestone inclusions and this banding the rock shows no trace of sedimentary origin. Under the microscope it is seen to contain no clastic material and all the evidence, which is not however conclusive, seems to point to its having been originally a volcanic ash. At two localities a bed of banded jasper and iron ore, generally magnetite, is found, which belongs near the base of the horizon. A high bluff of trap in East Bay, probably a lenticular intrusion, must also be included in it. Except on this south shore of the eastern arm Formation III is everywhere covered by the waters of the lake, within the area studied. Sufficient evidence of its continuity is afforded however by the presence of bowlders from the characteristic iron ore horizon at several widely distant points. The thickness varies considerably but may be taken at a maximum of 600 feet.

Formation IV consists of interbedded eruptives, which may reach a maximum thickness of 1000 feet. The rock is very uniform in character, the variations occurring being mainly in texture. It is normally a massive, rather coarsely crystalline

greenish-gray rock, made up of plagioclase and hornblende, and is probably a diorite. Locally it includes layers of green schist which are to be regarded as mechanical derivatives, analogous to the chloritic gneissic phases of the basement granite. The formation is best seen south of the eastern arm, where it forms a long ridge running from Lake Margaret portage N.W. to Falls Bay, and in the two natural sections made by the shore line at both the northern and southern ends. Small patches are exposed at a number of localities about the lake. It is uncertain whether this is an intrusive sheet or a flow.

Formation V is a very calcareous green schist containing thin seams of limestone. The included layers are quite pure finely crystalline limestone. Thin sections of the less calcareous portion show that the rock consists of 50 to 60 per cent of calcite, and for the rest, of argillaceous material and secondary quartz. Originally it was probably in the main a very calcareous shale, with thin beds of limestone. The thickness is about 600 feet.

Immediately above the limestone comes Formation VI, a conglomerate, having a maximum thickness of about 100 feet. It varies in habit, from a hydromica schist, carrying many grains of quartz, the clastic character of which is evident in thin section, to a rather coarse conglomerate, the pebbles in which seem to be entirely of quartz and granite. The locality in which it may be best seen is on Falls Bay, on the shore east of Jack Pine Point.

Formation VII. The type rock of this horizon is a light greenish gray, massive, close textured rock, which weathers a light brown. In thin section it appears to be of eruptive origin, but owing to the complete alteration of the bisilicate it is uncertain whether it was originally a diabase or a diorite. Departing from this as a type, on the one hand are found members which show crystalline structure macroscopically, and on the other banded green schists which to the eye have every appearance of being altered sediments. Under the microscope however they show no trace of sedimentary origin. This banding is of two kinds. (1), a fine banding due to an alternation of thin seams differing slightly from one another in color and in texture. (2), a coarser, due to the interbedding of layers of the massive varieties with the schistose. These layers are of all thicknesses, from a few inches up to several feet. The structure, of both varieties, appears to be antecedent to the last folding of the series, since it is often greatly contorted, and frequently intersected by the regional cleavage, and in general is parallel to the true strike. A graphitic schist, twenty feet or more in thickness, is also included. There is an

evident stratigraphical succession in the various members, the banded schists predominating towards the top. The peculiar gray green color and close texture are characteristic of the rocks of this horizon. The thickness is about 1400 feet.

Formation VIII. The agglomerate is best seen at Jack Pine Point and at locality 79 to the south of it. At locality 79, it consists of pebble-like inclusions, greatly resembling the type rock of Formation VI, imbedded in a light gray-green fissile matrix which is bright on the cleavage surfaces. The inclusions vary in size from a fraction of an inch up to 5 or 6 in. long diameter. They are elongated, and have rounded outlines, though tapering to rather sharp points. They are all of the same material, which is the same as the matrix apparently, differing from it only in lacking the schistose structure. They are hardly distinguishable from the matrix in color, on the fresh fracture, but on the weathered surface the inclusions stand out, and weather a lighter brown. Under the microscope the inclusions are seen to consist of an eruptive rock entirely similar to the massive form of VII. On Jack Pine Point the agglomerate is beautifully plicated and the inclusions follow the little folds. (Fig. 1.)

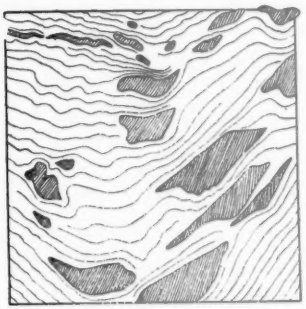


Fig. 1.—Agglomerate, Loc. The shaded inclusions in nature are lighter in color than the enclosing green schist. The waving lines indicate plications in the matrix.

Formation IX. Above the agglomerate, at locality 81 a fine grained clay slate is found, which besides a perfect slaty cleavage in the regional direction, shows alternating light and dark bands, which probably represent planes of deposition.

Structure.—The Steep Rock Series is folded into an eastern synclinal, a middle anticlinal and a western synclinal, which is faulted across the axis near the sharp turn.

A line drawn from the limestone exposure at the head of Falls Bay to Jack Pine Point indicates approximately the position of the axial plane of the eastern synclinal. East of this line the various members uniformly strike to the west of north. The dips are high to the S.W. ranging from vertical to 60, and on the average may be taken at 70. From the agglomerate at Jack Pine Point southward to the point north of Pine Beach, where the upper part of Formation IV is ex-

posed, the shore line again crosses the intermediate formations in descending order, the strikes bending round gradually to N. 20° E. A line drawn a little west of south through the eastern point of the limestone of the Elbow marks the intersection of the axial plane of the middle anticlinal with a horizontal plane. West of this line the limestone of the Elbow, Formation VI, and the various members of Formation VII, which alone are exposed on the southern and western shore, strike again to the northwest, gradually bending round along the latter to the east of north. The limestone at Conglomerate Bay abuts against a cliff of the basement granite, the line of separation marking the position of a fault. About 6000 feet S.W. along the line of this fault, which is well marked by a breccia in the peninsula N.W. of the upper narrows, Formations I and II are found again on the opposite side, striking N.W., and farther north on the large island in N.W. Bay, bending round again to the southwest. On the west shore of the lake west of N.W. Bay green slates, probably belonging to Formation VII, are found west of Formation II, and again on Birch Point indicating another fault which trends to the west of north. These two faults so complicate the structure of the western part of the lake, that the relations of the rocks, which are all recognizable as belonging to one or another of the IX formations of the series, could not be worked out in the time available.

There are two points in the general structure of the rocks of the lake which are especially noteworthy and significant. They are:

1st. The high pitch of the axes of the great folds. At the turn of the middle anticlinal at the Elbow, dips, which are well marked in the limestone, range from vertical to 75° to the south, (Section II.) At the turn of the western synclinal in Northwest Bay the dip is about 60° in the same direction. We have here, then, folds with very high south-pitching axes, the pitch in the case of the anticlinal being nearly 90° and in the case of the synclinal at a lower angle. In the case of the eastern synclinal the pitch is also high, though apparently considerably less than 90°, as indicated by the greater thickness of the series measured along the axis than across it. The Steep Rock series therefore dips away from the granites, at the turns of folds, at angles which do not differ materially from those observed in the long straight stretches; as, for example, that in East Bay.

2nd. The regional cleavage. Throughout the whole area is observed a regional cleavage, which has a tolerably uniform direction between the limits N. 38° and N. 48° E., and traverses all the rocks of the region, both the eruptive and sedimentary members of the Steep Rock Series, and the rocks of basement complex. It has largely obliterated the original

lamination of the sediments and banded schists of the Steep Rock Series, and is now the dominant structure.

In inferring the orotechnic history of the region the origin of the N.E. cleavage must be ascribed to a force acting perpendicular to it, or in a N.W. and S.E. direction; and since this cleavage runs through, and in many cases masks all previous structure, the force which produced it must have been the last force which has left its marks upon the rocks of the lake. To this force also must be ascribed the action which left the Steep Rock series in its present folded attitude.

What was the position of the rocks just before this cleavage-producing force acted upon them? It could not have been horizontal, for in the long stretch in East Bay, where the strike runs nearly straight for four miles, and in the limestone exposures N.W. of the Elbow, the plane of the dip nearly coincides with the direction of this force, and the cleavage planes intersect it nearly at right angles. A N.W. and S.E. force acting parallel to the present strike in the plane of the dip, could not have tilted these portions of the Steep Rock Series into their present nearly vertical position. It seems necessary to suppose, therefore, that before the cleavage-producing force acted, that part of the Steep Rock Series that we know, existed as a N.W. and S.E. striking monocline, having a high dip to the S.W. as the result of previous folding by a N.E. and S.W. force.

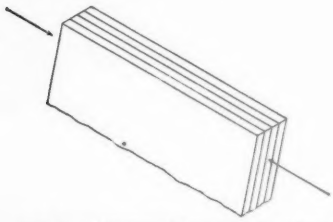


Fig. 2.—Diagram showing the attitude of the Steep Rock Series just previous to the second folding.

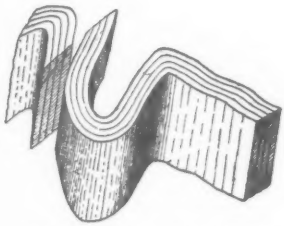


Fig. 3.—Diagram showing attitude of Steep Rock Series after second folding.

The folding of the Steep Rock Series indicates therefore two periods of orotechnic action. In the first period, the force acted in a N.E.–S.W. direction, and folded the series about horizontal axes, having a N.W.–S.E. direction. That part of the series now exposed about the lake was left as a N.W.–striking monocline, with a high dip towards the S.W. In the second period, the cleavage-producing force acted in a N.W.–S.E. direction upon this monocline and produced upon it two effects. 1st, it caused it to yield as a whole, not by vertical arching over horizontal axes, to which the nearly vertically

standing leaves of the series would oppose their maximum rigidity, but by horizontal buckling about nearly vertical axes, to which the opposed rigidity would be a minimum. Figures 2 and 3 illustrate this point. 2nd, consequent upon the regional movements attending the folding were produced minute fissures, and a rearrangement of particles along planes perpendicular to its direction; or, in other words, the regional cleavage.

These two periods of orotechnic action explain also the schistose dikes and the transition zones between Formation I, and the granitic complex. The dike at locality 41 will serve as an example of the class. It is from 60 to 70 feet in width and cuts the granitic complex, the southeast wall running N. 48° E. For a distance of three feet from the wall the dike is very schistose and fine grained. The interior is massive and crystalline. Under the microscope the interior is seen to be a quartz diorite, consisting of quartz, plagioclose, hornblende,—in places altered to chlorite and epidote, magnetite and apatite. The feldspars are nearly all saussurized. A slide from the schistose portion shows it to be a hydromica schist, with a great deal of normal chlorite. The quartzes are strained and broken, and the magnetite is granulated and drawn out into fissured "augen." Some epidote is arranged along planes of foliation. The rock shows shearing and crushing in an eminent degree.

Previous to the first orotechnic period we may suppose that the Steep Rock series lay in a horizontal position upon the basement complex. The parallel dikes, of which 41 is an example, which supplied the materials for the interbedded eruptives of the series, constituted a system of thin vertical beds running through and binding together the grantitic complex, and the sediments and interbedded eruptives of the upper series. The effect of the first force was to arch the series about horizontal axes parallel to the present strikes in East Bay, and perpendicular to the course of the chimney series of dikes. It acted parallel to the direction of these dikes and therefore opposed to their greatest rigidity. As the upper series bent under the action of the force, there must have been a difference in the rate of yielding of the bedded sediments and thin horizontal eruptives, on the one hand, and the vertical dikes and massive granitic complex on the other. This difference in rate of yielding must have produced grinding: 1st, of the basal sediments on the granitic complex; 2nd, between the vertical dikes and the rocks through which they passed, whether sediments, interleaved eruptives, or of the complex.

The grinding would result in shearing and comminution of both rocks in zones adjacent and parallel to the contacts. The

transition zone at the junction of the basement complex and Formation I, represents the depth to which the granites, previously weakened by disintegration, were affected by the grinding. In this zone there was also doubtless a certain intermingling of particles produced by the action of gravity.

The later orotechnic force has imposed schistose structure in these zones of comminution just as in the sedimentary members of the upper series.

Behavior of the complex.—How have the crystalline rocks of the basement complex yielded to the tremendous stresses which produced the buckled folds in the upper series? This most interesting question must be left incompletely answered. A few points, however, are clear. Great relief was afforded by the fault across the northern end of the lake. The dip of the fault plane, unfortunately, was not observed, but it is conceived that the movement was essentially horizontal, and that the 6000 feet of observed throw is nearly the full measure of its amount. In the zone adjacent to the Steep Rock Series, in which alone the granites were studied, the presence of numerous folded dikes, in the localities in which the whole series has been specially folded, seems to show that the granites yielded by bending and not by faulting. One of these is shown in figure 4. It is one of many seen in the stretch of shore north of Wiegand's Point. This bending in the granites implies, of course, according to Heim's law, a tremendous load upon them.

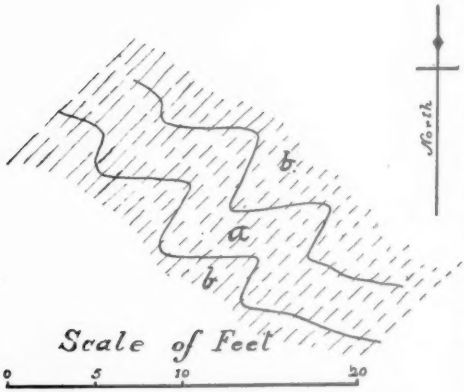


Fig. 4.—Plan of folded Dike. *a*=Greenstone Dike. *b*=Chloritic gneiss, autoclastic from granite. The surface dips gently to the North, 15°.

Thickness.—The thickness of the members of the Steep Rock series given in the description of the separate formations, is that measured in the section across East Bay, and is undoubtedly too great. This part of the series underwent tremendous longitudinal compression by the cleavage-producing force; the thinly bedded members have been thrown into little compressed folds, and the more massive members have been contorted on a larger scale. In both ways

the thickness of the series measured in section has been largely but indeterminately increased. In the stretch from the Elbow north to the head of Falls Bay, west of the axial plane, the series is much thinner, probably as the result of three causes: (1) A general stretching in this direction. (2) A possible faulting along the axis. This has not been observed, however. (3) A probable thinning out of the trap horizon in going west.

For these reasons a measurement across the series there would probably be at least as much less than the true thickness as the East Bay section is greater. A mean between them, or 4500 feet, may be taken as an approximation to the true thickness.

General Considerations.—The study of the Steep Rock series shows some results both positive and negative which have a general interest in connection with the geology of the region N.W. of Lake Superior.

1st. The contact of Formation I with the basement complex is one of erosion.

2d. The complex at the time of the deposition of the Steep Rock series was made up of consolidated crystalline rocks, and there is no evidence whatever that it has since undergone fusion, or recurred to the condition of a magma.

3d. The rocks of the Steep Rock series have been subjected at two periods, more or less distant, from one another, to the action of great orotechnic forces, which acted—the first in a N.E. and S.W. direction, and the second in a N.W. and S.E.

4th. The latter force has imposed upon all the rocks of the region a N.E. structure, which has largely, but not entirely, obliterated preëxisting lamination in the sediments and schists of the Steep Rock series.

5th. The two orotechnic actions have produced great developments of autoclastic* schists, both in the granites and in the rocks of the Steep Rock series; the present structure in which was induced and determined in direction by the last force.

The consideration of the Aticokan series, with a more general discussion of the mutual relations of the three series of rocks, and an attempt at correlation, must be deferred to another paper.

The author wishes to express his great obligations to Prof. Raphael Pumpelly for many valuable suggestions. Mr. C. Livy Whittle, of Cambridge, Mass., has kindly examined a number of thin sections from the Steep Rock series, and the results of his study are incorporated in the above description of formations.

Port Arthur, Ontario, June, 1891.

* That is, schists formed in place from massive rocks by crushing and squeezing, without intervening processes of disintegration or erosion, removal and deposition.

ART. XXXII.—*On the so-called Amber of Cedar Lake, North Saskatchewan, Canada;* by B. J. HARRINGTON, McGill College, Montreal.

THE occurrence of mineral resins in some of the coals and lignites of the Northwest and British Columbia has been known for many years, and the results of a partial examination of specimens from three localities were published by the writer in the report of the Geological Survey for 1876–77, p. 471. The conclusion then arrived at was that none of the specimens could be referred to amber or succinite, though in some respects closely resembling that substance. Attention was also called to the statement of Goeppert that he knew of no instance of true amber being found in the brown coals of northern Germany, the substance occurring in those beds being "retinite."

During the summer of 1890, Mr. J. B. Tyrrell, M.A., of the Geological Survey of Canada, visited a locality on the west shore of Cedar Lake, near the mouth of the North Saskatchewan, where a mineral resin resembling amber in appearance has been found in large quantity. With regard to it Mr. Tyrrell says: "It occurs mixed with sand and many fragments of partly decayed wood, on a low beach behind a gradually shelving shore and along the face of a deep, wet, spruce swamp. The pieces were, for the most part, smaller than a pea, but could be readily seen glittering among the sand and vegetable debris. Some pieces were found as large as a robin's egg, and Mr. King [of the Hudson's Bay Company] informed me that he had collected pieces very much larger. It has evidently been washed up on the shore by the waves, but its exact age has not been positively determined.

"The first place at which it was seen was in a small bay behind a limestone point projecting towards the north, but the most extensive deposit is more than a mile south of this point, where a rounded beach stretches across the margin of a low swamp. This beach is about a mile in length and from eighty to one hundred and twenty feet in breadth. The amber is found most plentifully along its ridge, where it constitutes between five and ten per cent by volume of the sand and vegetable debris, and holes dug to a depth of two feet show no diminution in its quantity. Towards the edge of the lake, however, the sand is freer, both from fragments of wood and amber. It is difficult to make an accurate estimate of the quantity of amber on this mile of beach, but it may confidently be said to be found throughout the distance in a band thirty feet wide, with a minimum depth of two feet."*

* Summary report of the Geological Survey Department for 1890, p. 22

The writer is indebted to Mr. Tyrrell for specimens of this so-called amber from Cedar Lake, and the results of their examination, as far as completed, will now be given. The substance was in pieces, for the most part very irregular in shape, some being more or less angular, others approximately spherical, and others flattened, discoid or lenticular. Some of the pieces were smaller than a pea, but they ranged from this up to the size of an ordinary bean (about 2 centimeters long). In color they varied from pale yellow to dark brown, and many, when examined by transmitted light, appeared clouded or banded from the presence of black carbonaceous matter. Superficially they were generally dull, owing, perhaps, to chemical change, but on fresh surfaces the luster was resinous. The fracture was conchoidal. Though electric on friction, they appeared to be less strongly so than ordinary amber.

Light-colored fragments, free from black carbonaceous matter, were selected for examination, and any superficial crust carefully removed by scraping. The hardness of these selected pieces was fully $2\frac{1}{2}$. The specific gravity, as obtained with a quantity of material in the specific gravity bottle, was 1·055 (at 20° C.), and a single fragment gave by suspension with a hair 1·0543 (20° C). The material for analysis was finely powdered and dried over sulphuric acid *in vacuo*. The combustions were made with lead chromate in the usual way, and the ash determined with a separate portion in a platinum crucible. The following are the results obtained:

	I.	II.	Mean.
Carbon	80·01	79·91	79·96
Hydrogen	10·37	10·55	10·46
Oxygen	9·53	9·45	9·49
Ash	0·09	0·09	0·09
	100·00	100·00	100·00

Excluding the ash the results become:

	I.	II.	Mean.
Carbon	80·08	79·98	80·03
Hydrogen	10·38	10·56	10·47
Oxygen	9·54	9·46	9·50
	100·00	100·00	100·00

The ash was brick-red in color and found to contain silica, alumina, iron, lime, and magnesia.

The only solvents whose action upon the resin has been tried as yet are absolute alcohol and absolute ether, and the effect of these was ascertained as follows: One gram of the finely pow-

dered resin was mixed with ten grams of pure quartz sand in a cylinder of filter paper and extracted in Soxhlet's apparatus, in the case of the alcohol for three and a half hours (24 siphonings) and in the case of the ether for two hours (24 siphonings). In each case the sand and filter paper were previously extracted by the special solvent for several hours. The extract from the resin was evaporated in a weighed platinum dish and the residue dried at 100° C. The results obtained were as follows:

Dissolved by absolute alcohol.....21·01 per cent.
" " " ether .....24·84 "

The effect of more prolonged action of the solvents has not as yet been ascertained. The alcoholic extract after drying was brownish in color, while that obtained with ether was only faintly yellow.

When small fragments of the resin were heated in closed tubes it was found that they began to soften at about 150° C., the point of softening being roughly ascertained by pressure with a platinum rod. At 180–190° C. the fragments were sufficiently yielding to be pressed into one mass by the platinum rod. Heated up to 300° C. the resin did not melt into a flowing liquid, put became soft and elastic, and had darkened a good deal from partial decomposition.

Fragments of genuine amber behaved in a similar manner, but began to soften at about 140° C. At 180° they could be readily pressed into one mass, and in the one experiment tried they seemed to darken more readily than the Cedar Lake resin when heated up to 280°–300° C. The ordinary statement that amber fuses at 287° C. is certainly misleading, the fact being that it begins to soften at a very much lower temperature, gradually getting softer and softer as the temperature rises, but not becoming a flowing liquid until decomposition takes place.

On heating the Cedar Lake resin in a test tube or retort no crystals of succinic acid were obtained, although they were readily obtained from true amber by similar treatment.

It is customary to assign to amber the formula $C_{40}H_{64}O_4$, which gives: carbon 78·94, hydrogen 10·53, oxygen 10·53; but this is apparently based upon very insufficient data—so far as the writer is aware, upon the single analysis of Schrötter (carbon 78·82, hydrogen 10·23, oxygen 10·95), which really corresponds much more closely to $C_{39}H_{60}O_4$. Such a substance as amber, too, coming from a variety of localities and originally derived from very different plants can scarcely be expected to agree closely in composition with one definite formula.

The Cedar Lake resin contains more carbon than the amber analyzed by Schrötter and less oxygen, and in this respect comes nearer to Walchowite and to some of the recent copals from India. The relations of some of these bodies will be made plain by the following tables:

	Carbon.	Hydrogen.	Oxygen.	Ratio of C, H, and O atoms.	Ratio of C, H, and O atoms, taking C = 40.
I. Amber	78·82	10·23	10·95	9·60 : 14·95 : 1	40 : 62·29 : 4·16
II. Krantzite	79·25	10·41	10·34	10·22 : 16·11 : 1	40 : 63·05 : 3·91
III. Cedar Lake Resin	80·03	10·47	9·50	11·23 : 17·63 : 1	40 : 62·79 : 3·56
IV. Copal (Bombay)	79·70	10·40	9·90	10·75 : 16·83 : 1	40 : 62·62 : 3·72
V. Copal (Calcutta)	80·34	10·32	9·34?	11·46 : 17·67 : 1	40 : 61·67 : 3.49

I. Phillips' Mineralogy (1852), p. 630. Anal. by Schrötter. II. Dana's Mineralogy (1869), p. 741. Anal. by Landolt. IV. Watts's Dictionary of Chemistry (ed. i.), vol. ii, p. 19. Anal. by Filhol. V. Watts's Dictionary of Chemistry (ed. i), vol. ii, p. 19. Anal. by Filhol.*

Though resembling amber in some of its characters, the Cedar Lake resin may here be classed provisionally as "retinite," on account of its differing from amber in its deportment with solvents,† in not yielding crystals of succinic acid on distillation, and in having a somewhat different ultimate composition. The name retinite as used by some mineralogists is a convenient general term to include such substances as Walchowite, Krantzite, Jaulingite, Rosthornite and the Cedar Lake resin, which last, by way of distinguishing it from other retinites, may be called Chemawinite (from Chemahawin or Chemayin, the Indian name of a Hudson Bay post, not far from where the resin occurs).

Though the origin of this substance is not certainly known, there can be little doubt that it has been derived from one of the Tertiary or Cretaceous lignites occurring on the Saskatchewan. Some of these are known to contain resins, one of which, examined by the writer, was not essentially very different from the Cedar Lake material. It behaved similarly on heating, had a hardness of over 2, a specific gravity of 1·066, and dissolved in absolute alcohol to the extent of 29·30 per cent.

Some of the larger pieces of the Cedar Lake resin might, perhaps, be employed for ornamental purposes (beads, etc.), and possibly the material might be utilized by the varnish-maker. This question will be discussed when the examination of the resin is completed.

* In the last analysis, as given by Watts, there is an error. The total is given as 100, whereas it is really only 99·80. It is here assumed that the error is on the oxygen—the constituent determined by difference. A similar error occurs in Schrötter's analysis of amber, as given by Dana.

† The statements in works on mineralogy with regard to fossil resins are often vague and sometimes conflicting. Thus, in speaking of the action of such solvents as alcohol or ether, we are told nothing as to the strength of the solvent, the duration of its action, etc., and the results given are, therefore, often of little value.

ART. XXXIII. — *Geological Horizons as determined by Vertebrate Fossils;** by O. C. MARSH. With Plate XII.

IN 1877, the author endeavored to bring together some results of his researches in the Rocky mountain region and in other parts of the country, relating to the succession of vertebrate life.† This led to a comparison of the relative value of the three different groups of fossils; plants, invertebrates, and vertebrates, in marking geological time. In examining the subject with some care, the author found that, for this purpose, plants are not satisfactory witnesses; that invertebrate animals are much better; but that vertebrates afford the most reliable evidence of climatic and other geological changes. The subdivisions of the latter group, and, in fact, all forms of animal life, are of value in this respect, mainly according to the perfection of their organization, or zoölogical rank. Fishes, for example, are but slightly affected by changes that would destroy Reptiles or Birds, and the higher Mammals succumb under influences that the lower forms pass through in safety. The special applications of this general law, and its value in geology, readily suggest themselves.

In accordance with this principle, the author next attempted to define the principal geological horizons in the West which he had personally investigated, and then taking in each the largest and most dominant vertebrate form which characterized it, used the name for the horizon. In the same way, some of the principal horizons of the East were named, and the whole brought together in a section to illustrate vertebrate life in America.‡

The names thus given to various horizons were not intended to replace those already applied, but merely to supplement them, and by new evidence, to clear up those in doubt. The same principle had long before been found to work admirably in Europe, where certain characteristic invertebrate fossils, especially Ammonites, had served to mark definitely various subdivisions of a single formation. The wider application of the principle to vertebrate fossils, from their earliest known appearance to the present time, has already helped to complete the record of vertebrate life in America, and rendered an equal service to systematic geology.

Since this method of defining geological horizons by vertebrate fossils was first used by the author in 1877, many important

* Abstract of Communication made to the International Geological Congress Washington, D. C., August 28th, 1891.

† Introduction and Succession of Vertebrate Life in America. Address before the American Association for the Advancement of Science, Nashville, Tenn., August 30, 1877.

‡ The same address, Frontispiece.

discoveries have been made, especially in the West, and much information bearing on the subject has been obtained from various quarters. In 1884, the author revised and extended the first section for his monograph on the *Dinocerata*, and it seems fitting on the present occasion to bring together once more some of the later evidence, and place on record the more important horizons now known to the author by personal exploration, or by other investigations which he has verified.

The accompanying section, Plate XII, is designed to represent in outline, in their geological order, the successive horizons at present known with certainty from characteristic vertebrate fossils. The correlation of these horizons with those determined on other evidence is important, and considerable progress in this direction has already been made, but the results cannot be presented here.

In comparing the present section with the one first published by the author, it will be noticed that no vertebrates are yet known in the Archæan or Cambrian, but a single fortunate discovery in Colorado has recently carried back the first known appearance of Fishes, from the lower Devonian to the lower Silurian, or more specifically, from the Schoharie Grit to the Trenton.

The next point of importance is in the Triassic, in the horizon of the Connecticut river sandstone where so many foot-prints have been found, and attributed to Birds. Recent discoveries in these beds have shown that at least three distinct forms of carnivorous Dinosaurian reptiles, all of moderate size, lived at that period, and doubtless did their share in leaving foot-prints behind them. In two of the skeletons secured, the bones of the hind feet are still in position, and in life could have made some of the foot-prints previously discovered.

Near the base of the Jurassic, a new horizon may now be defined as the Hallopus beds, as here alone remains of the remarkable reptile named by the author *Hallopus victor* have been found. Another diminutive Dinosaur, *Nanosaurus*, occurs in the same strata. This horizon is believed to be lower than the Baptanodon beds, although the two have not been found together. The Hallopus beds now known are in Colorado, below the Atlantosaurus beds, but quite distinct from them.

The Baptanodon beds have been found at many localities, in Dakota, Wyoming, and northern Utah, everywhere beneath the Atlantosaurus beds, and having below them, at various localities, a series of red beds, which may, perhaps, contain the Hallopus horizon, but are generally regarded as Triassic.

Beside the two species of *Baptanodon* described by the author, the next vertebrate in importance, in the same horizon,

is a small Plesiosaur, which may be called *Parasaurus striatus*. One specimen only has been found in northern Wyoming.

The Atlantosaurus beds of the upper Jurassic are now known to be one of the best marked horizons yet discovered. They have been traced for more than four hundred miles along the eastern flank of the Rocky mountains, and nearly everywhere contain great numbers of fossil vertebrates, especially gigantic Dinosaurs and other reptiles, as well as many diminutive mammals of primitive types. The same deposits have been found on the western slope, with the Baptanodon beds beneath them.

The most remarkable of the new horizons recently determined are the Ceratops beds in the Laramie series, at the top of the Cretaceous. This horizon is as strongly marked as that of the Atlantosaurus beds, and has now been traced for nearly eight hundred miles along the eastern base of the Rocky mountains. Toward the north, it is underlaid by marine Cretaceous strata containing Fox Hill fossils, but further south, various older formations are found immediately beneath it. The overlying strata, when present, are usually of Tertiary age. The Fort Union Eocene beds on the upper Missouri, the Brontotherium beds of the Miocene in Wyoming, and further south in Colorado the Pliohippus beds of the Pliocene, may be seen immediately above. The vertebrate fauna of the Ceratops beds is remarkably rich and varied. The gigantic horned Dinosaurs named by the author the *Ceratopsidæ* especially abound, and determine the horizon with accuracy. Other Dinosaurs are numerous; and a few Birds, and various Mammals of Mesozoic types have also been secured.

In the various horizons of the Tertiary, as repeated in the present section, no changes of importance have been required, as more recent discoveries fully confirm their value and accurate determination.

SCIENTIFIC INTELLIGENCE.

I. Chemistry and Physics.

1. *On the Absorption Spectrum of Liquid Oxygen.*—In a preliminary examination of the absorption spectrum of liquified oxygen, Olszewski observed four bands corresponding to the wave lengths 628, 577, 535 and 480, these bands being the same as those noted by Liveing and Dewar in the spectrum of gaseous oxygen at high pressures, in addition to two bands in the ultra red agreeing with the Fraunhofer lines A and B. More recently Olszewski has prepared liquid oxygen in larger quantity and has examined its absorption spectrum more critically. Using a layer

30 mm. thick and 50 mm. high, contained in a thin glass vessel surrounded by three glass beakers to protect it from outside heat, it was found possible to maintain it at atmospheric pressure at its boiling point $-181{\cdot}4°$ for half an hour or more; and thus to submit it to observation for that time. The four absorption bands above mentioned were observed, and in addition a fifth band corresponding to the Fraunhofer line A, more intense than the band of wave length 535 but less so than the others. No absorption band corresponding to the line B was seen. In 1883 liquid oxygen was described as colorless; but with larger quantities, the author has noticed that in a layer of greater thickness than 15 mm., it has a distinct blue color by transmitted light. Since special care was taken in the purification of the gas, and since ozone was proved to be absent, the author believes this color to be characteristic of liquid oxygen. Moreover, he suggests that the blue color of the sky may be due to the oxygen in the atmosphere.—*Ann. Phys. Chem.*, II, xlii, 663; *J. Chem. Soc.*, lx, 773, July, 1891. G. F. B.

2. *On the Production of Ozone in Rapid Combustion.*—The statement of Ilosvay that ozone is not produced in rapid combustion having been questioned, he has reëxamined the matter and concludes that the tests by which the presence of the ozone was established by Loew and Cundall were not satisfactory. He finds that neither in the products of combustion nor in the air taken from around a flame is any substance present which (1) gives the odor of ozone, (2) renders thallous oxide paper brown, or (3) permanently decolorizes a solution of sulphophenyl-azo-*α*-naphthylamine so that naphthylamine no longer restores the color. By carefully depriving the gas used of sulphur compounds, he obtained in only a single experiment a reaction with thallous oxide paper; and this after about seven hours. Taking special precautions to keep the temperature of the flame low, however, and employing a special collecting apparatus, he obtained the thallous oxide reaction in about 4 to 5 minutes and the other reaction in 10 to 15 minutes. Examined in this way the author finds the flame of methane to give less, the flames of hydrogen and carbon monoxide more ozone than that of illuminating gas. Moreover it appears that the relative amounts of nitrous acid and ozone formed by a flame depend upon its temperature and upon its surface; the ozone formation being favored by a low temperature. Oxygen did not give as good results as air. Even if the oxygen is partially converted into ozone by blowing a current of this gas or of air on a flame, this fact the author thinks does not contradict his statement that ozone is not formed during rapid combustion. These results agree with those of Dewar and those of Elster and Geitel. The former chemist ozonized oxygen by passing it over white hot platinum. Since therefore the conditions essential to the production of ozone are not present in ordinary combination, this cannot be the source of the ozone of the atmosphere.—*Bull. Soc. Chim.*, III, iv, 707; *J. Chem. Soc.*, lx, 798, July, 1891. G. F. B.

3. *On Sulphuryl Peroxide.*—By the action of the silent electric discharge upon a mixture of either sulphuric oxide or sulphurous oxide and oxygen, Berthelot obtained several years ago a crystallized compound to which he gave the name persulphuric acid and the formula S_2O_7. The same substance was also obtained by Berthelot by the electrolysis of a 40 per cent sulphuric acid. Shortly afterward TRAUBE made a preliminary examination of this compound and concluded that its formula was SO_4 and not S_2O_7; and further that it was not an acid oxide as Berthelot supposed, but a neutral substance, sulphuryl peroxide. The present paper deals with the analytical results of his investigation. Although he has not succeeded in isolating the peroxide, he has obtained it free from the 40 per cent sulphuric acid in which it was dissolved. This was done by diluting the solution with 2 to 4 times its volume of water and adding to it freshly prepared barium phosphate. The sulphuric acid is thrown down as barium sulphate and the filtrate contains the peroxide dissolved in phosphoric acid with some barium phosphate. It does not seem capable of existing in solution in pure water. As the peroxide easily evolves oxygen and is reduced to sulphuric oxide, the composition of the dissolved compound was ascertained by taking a known volume of the solution, determining first the active oxygen therein by a known solution of ferrous sulphate, titering back with permanganate, and then the sulphuric acid as barium sulphate. In two experiments, the active oxygen was found to be 9·62 and 35·96 milligrams, the SO_3 present being 49·5 and 178·5; giving the ratio 1 : 5·1 and 1 : 5 in the two cases. Hence 16 parts active oxygen are combined with 80 parts of SO_3; i. e., $SO_3 + O = SO_4$; or perhaps $(SO_3) + O_2 = S_2O_8$. In order to determine its neutral character, the electrolyzed sulphuric acid after dilution with one to two parts of water and cooling to $-10°$, was saturated with dilute alkali; a process which did not affect the SO_4. On boiling the neutral solution thus obtained for a half hour, until a drop gave no blue coloration with zinc-iodide-starch solution, the active oxygen was expelled and the solution became intensely acid. Evidently if the peroxide had been an acid oxide and had formed an acid with the water present, a salt K_2SO_5 would have resulted from the saturation of this acid by potassium hydroxide. And this on giving up oxygen would have produced K_2SO_4 still neutral. This evidence of neutrality on the part of the peroxide was confirmed by quantitative data. The ratio of the active oxygen in the solution before boiling to the sulphuric acid produced by the boiling was determined; the acid by titration with sodium or potassium hydroxide, using rosolic acid as an indicator; and the active oxygen either by ferrous solution and permanganate or by potassium iodide and sodium thiosulphate. The ratio varied from 1 : 4·56 to 1 : 5·10; giving 1 : 4·85 as a mean. The active oxygen as determined by the iron method was somewhat higher than that given by the iodine method, owing to the presence of acid carbonate of the alkali in the solution, which decreased the free acid

in this solution and also decreased the quantity of the active oxygen as determined by the iodine method. The author regards this compound either as sulphuric oxide in which a single atom of oxygen is replaced by a double one, $SO_2(O_2)$ or as hydrogen peroxide in which the hydrogen is replaced by SO_2, corresponding to Brodie's class of neutral peroxides. Berthelot's S_2O_7 he regards as $SO_4 + SO_3$. Since in not too dilute sulphuric acid, it dissolves without evolution of oxygen, the equation $S_2O_7 + H_2O = H_2SO_4 + SO_4$ shows the identity of the product thus obtained with that produced by electrolysis.—*Ber. Berl. Chem. Ges.*, xxiv, 1764, June, 1891. G. F. B.

4. *A Dictionary of Applied Chemistry;* by T. E. THORPE assisted by eminent contributors. Vol. II, 714 pp., 8vo. London, 1891, (Longmans, Green & Co.)—The first volume of the Dictionary of Applied Chemistry—the successor, on the technical side, to Watts's Dictionary of Chemistry—was noticed in volume xxxix of this Journal, (p. 519). The second volume has now appeared and carries the work on from Eau to Nux, and hence the completion of the whole may be looked for at an early date. Some of the more important subjects discussed at length, and in many cases with liberal illustrations, are the following: Explosives, by W. H. Deering; fermentation, by P. F. Frankland; fuel, by B. H. Brough; coal gas, by Lewis Wright; gold, by E. J. Ball; india rubber, by C. A. Burghardt; iron by Thomas Turner; lead by P. P. Bedson; matches, by E. G. Clayton; napthalene, by W. P. Wynne. The same thorough but concise treatment before noted characterizes this volume and makes the work as a whole indispensable to all interested in any of the many departments of technical chemistry.

5. *Measurement of time of Rotation.*—The ordinary methods of determining the time of very rapid rotation depend in general upon the contact of a stylus on the prong of a tuning fork with a rotating wheel or cylinder, or on the use of the electric spark with a pendulum to indicate the time of rotation. K. PRYTZ departs from both of these methods and employs a falling body upon or against which the rapidly rotating body spirts a fine jet of coloring matter. In this way retardation of contacts is prevented, and the time is referred directly to the time of a falling body. The author gives in detail the method of holding the small glass tube containing the coloring matter, and the method of obtaining the records. Examples of determination of time by this method are given and the author claims that the time of a complete revolution of his apparatus could be determined to 0·00002 of a second.—*Ann. der Physik und Chemie*, No. vii, 1891, pp. 638–651. J. T.

6. *Method of determining Specific Heat by means of the Electrical Current.*—The method of determining specific heats by the use of Joule's law has not proved useful, except in non-conducting liquids. Professor PFAUNDLER has obviated the difficulty of conduction through the liquid by employing glass

spirals filled with mercury. These spirals were placed in a Wheatstone's bridge in order to control the ratio of the resistance during the flowing of the current and to keep it constant.—*Wiener Berichte*, April 9, 1891. J. T.

7. *Optical relation of Organic Dyes.*—E. VOGEL discusses the sensitizing power of the various compounds of eosine and gives charts of the sensitizing power. He recommends for orthochromatic photography that ordinary dry plates containing a weak amount of iodide of silver should be bathed in the following: 25^{ccm} solution of the coloring matter, erythrosine, in water, (1:1000); $0{\cdot}5^{ccm}$ solution nitrate of silver (1:20 water); 2^{ccm} ammonia, spec. grav. 0·94; 75^{ccm} distilled water. The author finds that the eosine dyes which are the most strongly fluorescent are the poorest sensitizers. Among the other conclusions of the writer we find the following: The sensitizing power of the eosine dyes depends: 1. On the sensitiveness to light of the dye. 2. On the proportion of light rays that is absorbed in other than chemical work. The more energy of the latter that is consumed in other than chemical work the smaller the chemical action.—*Ann. der Physik und Chemie*, No. vii, 1891, pp. 449–472. J. T.

8. *Maxim's Flying Machine.*—It is stated that Mr. Maxim is now constructing a flying machine at Crayford, which is nearly ready for launching. "It will be propelled by a light screw making 2500 revolutions per minute. The motive power is said to be a petroleum condensing engine weighing eighteen hundred pounds, and capable of raising a forty thousand pound load. The real suspending power will lie in an enormous kite measuring 110 feet long and 40 feet wide."—*Nature*, July 30, 1891. J. T.

9. *Small Electrometers.*—At a meeting of the Physical Society held in London, June 26, Professor BOYS described small portable electrometers of his design. In one of these the needle was cross-shaped and made of zinc and platinum, and reliance was placed upon contact electricity to keep the needle at different potentials. The instrument was very sensitive.—*Nature*, July 16, 1891. J. T.

10. *Influence of brightness upon phenomena of interference of light.*—According to Michelson and Morley the red hydrogen line is a close double. They found that if the light of this line was employed to obtain interference bands, that these bands disappeared with a difference of path of 15,000 wave-lengths, and also with a difference of path of 45,000 wave-lengths, and from a similar phenomena produced by the double sodium line it was concluded that the hydrogen line H_α consisted of two components at a distance apart of $\frac{1}{6\,0}$ of that of the sodium lines. EBERT concludes from his investigation of this subject that this difference in the position of minima is not connected with duplicity of the line but depends upon particular conditions of the source of light; and believes that peculiarities in the appearances of the hydrogen line in stars of certain types depends also upon character of emission of the light. The method of high interfer-

ences promises to give an insight into the relation between the character of the light and the distribution of light in its spectral lines.—*Ann. der Physik und Chemie*, pp. 790–807, no. 8, 1891.

J. T.

11. *Thought transference.*—Professor LODGE, President of the section of Mathematics and Physics at the late meeting of the British Association, used the following language: "May there not also be an immaterial (perhaps an etherial) medium of communication? Is it possible that an idea can be transferred from one person to another by a process such as we have not yet grown accustomed to, and know practically nothing about? In this case I have evidence. I assert that I have seen it done and am perfectly convinced of the fact."—*Nature*, Aug. 20, 1891, p. 386.

J. T.

II. GEOLOGY.

1. *Fifth Triennial Meeting of the International Congress of Geologists.*—The International Congress commenced its sessions at Washington, on Wednesday, the 26th of August. The meeting was called to order by Prof. T. McKenney Hughes, of Cambridge, England. After the election of officers, in which Dr. J. S. Newberry was chosen President, the chair, in the absence of Dr. Newberry, was taken by Prof. Joseph LeConte, one of the Vice-Presidents. The principal subjects discussed during the sessions are the following: The Ice-period in America and northern Europe and the classification of pleistocene formations, which was opened by President T. C. Chamberlin and occupied Thursday; the Correlation of European and American geological formations, opened by Prof. G. K. Gilbert, occupying Friday; the Graphic system used in geological work, opened by Major Powell, on the forenoon of Monday. The afternoon of that day was given up to discussions relating to the geology of the regions to be visited by the Western excursion.

On the subject of Correlation, the value of the effects of physical events or conditions and of relations in flora, in fauna, in Invertebrate species and Vertebrate species was variously discussed. The weight of opinion appeared to favor the view that Vertebrate species, when present, afforded the best evidence as to chronological relations. Prof. Zittel gave the highest place to Vertebrates. An abstract of Prof. Marsh's remarks is contained in the paper on page 336.

The next meeting of the Congress, or that of 1894, will be held in Switzerland, probably at Berne; and, on special invitation received from the Geological Survey of Russia, the following, in 1897, will probably be held in St. Petersburg.

The party for the excursion to the Yellowstone Park, Colorado, etc., included about eighty members of the Congress, of which more than half were those from abroad. The following ladies were of the number: Miss Mary Forster of London, Mrs. Mary

Caroline Hughes of Cambridge, England, Madame Marie Pavlow of Moscow, Madame Henriette Sihleano of Bucharest, Roumania, Madame Maria G. Stefanescu of Bucharest, Mrs. S. F. Emmons, Miss Mary G. Markoe and Miss C. A. Smith, of Washington, and Mrs. H. S. Williams of Ithaca. Through the Park the party has the special guidance of Messrs. Hague and Iddings. The excursion will occupy 25 days; or for those who go also to the Colorado Cañon, an additional ten days. The latter trip is under the direction of Major Powell. A geological guide-book of 150 pages, prepared by Mr. S. F. Emmons, was distributed to members of the party. The party left Washington on the second of September.

2. *The Geological Society of America.*—The Geological Society held its Summer meeting in Washington on the 24th and 25th of August. The President of the Society, Prof. Alexander Winchell, having died since the preceding meeting, the chair was taken by Prof. G. K. Gilbert, Vice-President. Resolutions in honor of the late President prepared by a committee were offered by the chairman, Prof. Orton. An excellent memorial of Dr. Winchell was read by his brother Prof. N. H. Winchell.

Many foreign geologists were present at the meeting of the society and several presented papers having an American importance; among these were Prof. Alexis Pavlow, of the University of Moscow, on the marine beds terminating the Jurassic and Cretaceous and on the history of their fauna; Dr. Gustav Steinmann on a geological map of South America; Dr. Friedrich Schmidt, on the Eurypterus beds of Oesel as compared with those of the Waterlime of North America; Baron Geràld de Geer, of Stockholm, on the Quaternary changes of level in Scandinavia; Prof. A. N. Krassnof, of Russia, on the black earth of the steppes of southern Russia and its relations to the soil of the American prairies. Of the other valuable papers, that of C. D. Walcott, on the Lower Silurian ichthyic fauna presented in full the evidence he had obtained in favor of his announced discovery, carrying down the first fossil fishes from the middle Upper Silurian to the Trenton Period in the Lower Silurian. The associated fossils were examined by Prof. Hall and pronounced by him, as decided by Mr. Walcott, unquestionably Trenton.

3. *A United States Association of Government Geologists.*—A meeting was held at the Columbian University August 28, having for its object an official organization of the directors of the state and national geological surveys. There were present Maj. J. W. Powell, director of the United States Geological Survey, and the state geologists: Prof. James Hall, of New York; Prof. J. M. Safford, of Tennessee; Prof. J. W. Spencer, of Georgia; Prof. E. A. Smith, of Alabama; Prof. J. A. Holmes, of North Carolina; Mr. Arthur Winslow, of Missouri; Mr. E. T. Dumble, of Texas; Prof. J. Lindahl, of Illinois. Maj. Powell was elected chairman of the meeting, and Mr. Winslow secretary. After a few preliminary remarks in explanation of the reasons for calling the meeting, Mr. Winslow read a paper suggesting a plan of

organization and explaining the objects of, and the results to be derived from, such an official organization. The following are among the important objects in view :

The determination of the proper objects of public geological work ; the improvement of methods ; the unification of methods ; the establishment of the proper relative spheres and functions of national and state surveys ; coöperation in works of common interest and the prevention of duplication of work ; the inauguration of surveys by states not having such at present to coöperate with the other state surveys and with the national survey.

A committee of six was elected to consider the matter of organization, with the power to frame a constitution and by-laws, to be reported to the association at a time and place to be selected by the committee. This committee consists of Maj. J. W. Powell, chairman, and Prof. E. A. Smith, Prof. J. A. Holmes, Dr. J. C. Branner, Mr. Arthur Winslow, and Prof. N. H. Winchell. At the meeting of the Committee, Saturday evening, Aug. 29, the secretary, Mr. Arthur Winslow, was instructed to draft a constitution and by-laws to be submitted to the committee at a meeting to be called in connection with the annual meeting of the Geological Society in December next. The object of the association is an important one and much good should come from it.

4. *The Fauna of the Lower Cambrian or Olenellus Zone;* by C. D. Walcott. pp. 511 to 774, with plates xliv to xcviii of the Tenth Annual Report of the Director of the U. S. Geol. Survey. —Mr. Walcott, who has added greatly by his labors to the knowledge of Cambrian life and geography, gives a review in this memoir of his former work on the fauna of the Lower Cambrian, with additions from his more recent results. After a chapter on the history of Cambrian discovery, the stratigraphy of the Cambrian is reviewed and its distribution over the American continent and elsewhere, as at present known, is described. The latter subject is illustrated as regards America by a map on which sections are drawn for each locality having their relative heights ; and the former by various actual sections, some of which show contacts with older rocks. Mr. Walcott observes that the fauna lived, not on the outer coasts of America but in interior straits or channels between emerged ranges of older rocks ; that it occupied the eastern and western portions of the continent, but that "as far as known, the Lower Cambrian is absent from the interior of the continent," indicating thereby, he says, very uniform condition over the central portions. He remarks that the Upper Cambrian sea is shown to have been transcontinental by the presence of identical species of fossils in Northern New York, Lake Champlain valley, St. Lawrence valley, Tennessee, Alabama, Wisconsin, Minnesota, Texas, the Black Hills of Dakota, Nevada and Montana. In the Olenellus period, also, there was a similar assemblage of forms on the opposite sides of the Continent.

The chapter on the Geographical distribution goes into details as to the rocks and species of each locality over the Continent,

with comparisons of the special fauna. It is followed by another on the relations of the Lower Cambrian fauna to those of the overlying Cambrian.

This latest review of the species makes the tribes represented in the American Lower Cambrian include: Sponges of four genera; Hydrozoa of the group of Graptolites, and perhaps Medusæ; Actinozoa or true Coral polyps; Echinoderms, of the group of Cystids; Annelids; Brachiopods of 10 genera and 29 species; Lamellibranchs, probably of two species; Gasteropods, of the genera Stenotheca, Platyceras and Pleurotomaria; Pteropods, of 4 genera and 15 species; Crustaceans of Ostracoid type, of the genera Leperditia, Aristozoe and Isoxys; and of the Phyllopod type, in his Protocaris; and Trilobites of 16 genera and 53 species.

Notes of new facts and views relating to the genera and species follow, his former papers being referred to for full descriptions. Fifty plates of figures of the various species close the memoir. Mr. Walcott observes that nothing is learned from the rocks with regard to the genesis of these Lower Cambrian types.

5. *Relation of secular Rock-disintegration to certain transitional crystalline schists;* by R. PUMPELLY (Bull. Geol. Soc. Amer., ii, 209).—This paper is a very valuable contribution to geological science. Some of its facts and conclusions are here cited. A dike of basic rocks intersecting the pre-Cambrian Clarksburg mountain gneiss, near Williamstown, Mass., does not pass up into the overlying Cambrian quartzyte. The dike bears evidence of having been decayed before covered by the quartzyte; and thus leads to the conclusion that the region was dry land before the deposition of the Cambrian. In Hoosic Mountain, which has a core of pre-Cambrian granitoid gneiss, this gneiss has over it a formation, in an anticlinal, consisting of well defined conglomerate at the north end, a gneiss with parallel foliation on the east, a fine-grained, white gneiss, with little mica and rather obscure foliation on the west. The lateral transition of the Lower Cambrian quartzyte of the valley was traced into these white gneisses, "definitely settling the Cambrian age of this conglomerate-gneiss formation." At many points there is complete structural conformity between the pre-Cambrian and the overlying Cambrian gneiss. But on the Clarksburg mountain, where similar facts occur, the quartzyte mantling the granitoid gneiss is crinkled into minute fan-like plications, and the granitoid gneiss has similar plications in perfect parallelism. This fine lamination disappears a short distance from the line of contact. It is evident, says Mr. Pumpelly, that this structure in the older rock was formed at the same time and by the same pressure as that in the younger. The hypothesis of a pre-Cambrian decay of the granitoid gneiss affords a key to the problem in the Green mountains here exemplified. The transitional beds between the two rocks are made of the results of

this decay. The apparent conformity in foliation is due to the shearing action consequent on the slipping movement.

About Iron Mountain, Missouri, Mr. Pumpelly observed, in 1873, evidence of ancient disintegration, and pointed out a conglomerate at the base of the mountain as of Silurian age, and a result of pre-Silurian disintegration. Borings recently made by Prof. W. B. Potter have resulted in the discovery of extensive areas of residuary ore-fragments lying on the pre-Silurian surface.

Mr. Pumpelly has under investigation the Archæan rocks of New England and their relations to the associated rocks, and his paper shows that he has already reached results of great importance.

6. *The Greylock Synclinorium;* T. NELSON DALE (American Geologist, July, 1891).—This paper is an abstract of a Report to R. Pumpelly, U. S. Geological Survey. The chief conclusion confirms the view of Emmons and later observers that the Greylock mountain mass is synclinal in general structure. The author makes it a combination of synclinals and anticlinals, but chiefly of two large synclinals. His paper is illustrated by one of the several sections which will appear in the full report.

7. *Report on the Arkansas Geological Survey for 1888*, Vol. IV. JOHN C. BRANNER, State Geologist. 262 pp. 8vo, with many plates. Little Rock, Ark., 1891.—This concluding volume of the Report for 1888, is occupied with an account of the geology of Washington Co., by F. W. Simonds, Assistant Geologist, and a list of the plants of Arkansas by J. C. Branner and F. P. Coville. The rocks include four strata of limestone alternating with sandstones and shales of the Lower Carboniferous (Subcarboniferous), with a thin stratum of shale at the base, probably Devonian, and the Millstone Grit, of the "Barren Coal Measures," at the top. The lowest limestone abounds in chert. The greatest thickness given for the Millstone grit is 500 feet, and for the formations below less than 300 feet.

8. *Tungsten minerals in Canada;* by W. F. FERRIER, Geol. Survey of Canada. Communicated by permission of the Director, ALFRED R. C. SELWYN.—I have lately made an interesting discovery of tungsten minerals at a Canadian locality, some of them occurring in remarkably fine crystals. This is the first time that this metal has been noted in Canada. A detailed description is in preparation and will shortly appear.

Geological Survey of Canada, Ottawa.

III. BOTANY.

1. *Some Museums and Botanical Gardens in the Equatorial Belt and in the South Seas* (Third Paper).—Before describing the remaining gardens in Australasia, it will be well to make mention of the *Technological Museum at Sydney*, which contains illustrations of the valuable treatise on the useful plants of Aus-

tralia, by Mr. J. H. Maiden. After the fire which destroyed the Sydney Exhibition building, in September, 1882, Mr. Maiden began the discouraging task of forming a new collection of technological products. The building which was placed at his disposal was formerly the Agricultural Hall of the Exhibition, and is only poorly adapted to the purpose of displaying specimens. In the part of this simple structure which is in his charge, he has brought together an exceedingly large and valuable Museum, which possesses so many features of practical interest for a new country, that no apology will be needed for giving it here what may seem at first to be a disproportionate amount of space. The classification includes (1) Animal products, exclusive of foods. (1a) Economic entomology. (2) Vegetable products, from the raw material through the various stages of manufacture to the finished fabric or other article. This section includes gums, resins, oils, woods, fibers, tans, dyes, drugs, perfumes, Forestry and forest products. (3) Waste products. (4) Foods. (5) Economic Geology. (5a) Ceramics. (5b) Glass. (6) Original specimens of artistic workmanship, coins and medals. (7) Photographs, electrotypes, plaster and other reproductions of examples of art workmanship, where originals are not to be obtained. (8) Ethnological specimens. (9) Metallurgy. (10) Mine-engineering. (11) Strength of materials, etc. (12) Military and Naval. Fire-arms for hunting. Traps, etc. (13) Transportation. (14) Agriculture. (15) Instruments of precision. Apparatus for diagnosis, etc. (16) Sanitary appliances. (17) Educational arrangements. (18) Chemical and pharmaceutical products. (19) Models of patents. (20) Trade Journals. This outline of a classification which is substantially the same as that used at South Kensington, has been found well adapted to the wants of the young Colonial community, and might be found very useful in our smaller Technological Museums in this country.

It is, however, of the collection of products of plants brought under the heads, 2, 3, 4 and 11, that special mention should be made now. These are described in a work of about 700 pages by Mr. Maiden, *Useful Native Plants of Australia.* First come the human foods and food adjuncts. Then follow the forage plants and the plants which are noxious to stock. Other classes are: drugs, gums, resins, kinos, oils, perfumes, dyes, tans, timbers, fibers, and lastly a few miscellaneous products. The volume is, in fact, a capital catalogue of the specimens exhibited in the Museum, giving needed information regarding uses and sources. The indexes are copious and exact, with sufficient cross references.

The system of registering all accessions is nearly the same as that used in our National Museum at Washington, permitting the curator and his assistants to keep track of everything coming in and going out. The labels are full and instructive.

It was a pleasure to see the well-filled room on public days, reminding one of the divisions at South Kensington which are

profitably used by British workmen. Here, in a far distant colony, educational appliances of the same kind, specially adapted to the modified surroundings, are thoroughly appreciated by the public. The success has been so great that branch museums have been established in other parts of New South Wales, all under the care of the curator of the head office at Sydney.

As noted in a former paper, there are other technological museums in Australasia, somewhat on the plan of that at Sydney, and all of them are accomplishing much in the development of the colonies. It is pleasing to note, further, that these, together with the natural history and the art museums, are well supported, being everywhere in these colonies recognized as important factors in education. Some of these museums have been already referred to: in this communication reference must be made to still others. The Sydney Museum, under the curatorship of Dr. E. P. Ramsay is very rich in some of the departments, notably that of ornithology. At the time of my visit, in February, a large portion of the building was undergoing repairs and additions were being made. In Sydney, as in other centers of learning in the colonies, there are strong local societies for the encouragement of science, but until the formation of the Australasian Association for the Advancement of Science, there was no general organization. Professor Liversidge of Sydney, who was the prime mover in the establishment of the Association, must view with great satisfaction the happy results which have followed his successful work.

Brisbane, the capital of Queensland, is in latitude 27° 28′ S. and about five hundred miles north of Sydney (over 700 by rail). The climate is very much like that of northern Florida and permits a wide range of plants to be cultivated in the Botanical Gardens. There are two Botanic Gardens in this city, neither of them very large but both kept in good condition and of much use to the colony. The one which is properly a governmental establishment occupies a portion of one of the peninsulas formed by the curves of the Brisbane river, and, owing to its lying so low, is sometimes partly inundated by freshets. At the time of my visit, the traces of damage from one of these floods had not been wholly obliterated. The grounds contain many interesting sub-tropical plants with not a few which are truly tropical. Changes which have been inaugurated by the new curator, Mr. Philip MacMahon, promise to be substantial improvements both in selection and arrangement.

The other garden is close by the two parks, Bowen and Victoria, and attracts a large number of visitors on pleasant days. It is under the management of the Society of Acclimatization, and has for its curator Mr. Souter. The classes of plants are much like those in the government garden, but a good proportion of the specimens are older or at least larger. The propagating department was very interesting. A catalogue of the plants of

the gardens has been prepared by the active colonial botanist of Queensland, Mr. F. M. Bailey. The manual of the Queensland Flora by Mr. Bailey is full and convenient.

Mr. Bailey was formerly a resident of South Australia and possesses a large acquaintance with Australian plants. He places his knowledge most freely at the service of those who, like myself, have during a hurried journey, only a limited time in which to examine localities of special interest.

Attention should be called in passing to the fact that two Americans now fill positions of responsibility in the colonial departments of agriculture. These are Dr. N. A. Cobb, of Sydney, and Professor E. N. Shelton, of Brisbane. Dr. Cobb, formerly of Worcester, Mass., studied at Jena. He is now conducting investigations in animal and vegetable pathology in New South Wales. Professor Shelton is instructor in agriculture in Queensland. The writer is indebted to them and their associates for innumerable courtesies.

Of the remaining gardens in Australia proper, I had opportunity to examine with care only one, namely, that at Geelong. This is in the colony of Victoria, about fifty miles from Melbourne. It is situated delightfully on the shores of Coris Bay, and like many others of its class, is practically a city park. Such pleasure grounds differ from those in our own country chiefly in the prominence which is given to interesting species of plants. Not only are foreign plants used freely for decorative purposes, but they are chosen apparently with a view to impart to the park distinctive features as a botanic garden. Nearly all of the gardens, large and small, make great use of what are called bush-houses. These are simple frame structures roofed with slats having gaps between, admitting plenty of air, but affording shelter and shade. They are particularly adapted to Ferns and Aroids, and lend themselves readily to artistic treatment of foliage.

Tasmania.—In this colony I had the pleasure of visiting the garden at Hobart. In this a good deal of attention has been given to trees, especially Conifers, and the results are satisfactory. The garden is picturesque and interesting. Mr. Francis Abbott, the superintendent, finds himself considerably hampered by the scarcity of available labor, but he makes the most of the scanty means at command. The island itself is a botanical garden on a vast scale. Within a few miles of Hobart, one enters the thickets on the slopes of Mt. Wellington, surrounded by Eucalypts and tree ferns, and by flowers of extraordinary beauty. Even here one has at command a handbook of the local flora, namely, a work by Rev. Mr. Spicer. It is designed for schools, but it answers a good purpose for tourists in giving descriptions of the commoner plants of the island. The charming walk over the famous Huon road and up Mt. Wellington must not be omitted by any visitor who would see Tasmania vegetation at its best.

The New Zealand Gardens.—The southernmost one visited was at Dunedin, in Otago. It is a modest city pleasure ground,

supported on the most meagre allowance, but presenting some interesting features. The collection of rare New Zealand plants, made by Mr. John McBean, is worthy of attentive study. At Christchurch, in Canterbury, the garden is much more extensive. Its curator, Mr. Taylor, had but very lately taken charge, but he indicated certain improvements in prospect. The native plants are well shown by good specimens, a good deal of care having been taken to secure types and varietal forms. It was my good fortune to be conducted through this garden in one of my visits, by Professor Kirk, whose labors in connection with the New Zealand Flora are everywhere known. He is now engaged in editing a new edition of Sir Joseph Hooker's Handbook of the Flora of New Zealand, a work now out of print. Professor Kirk's Forest Flora of New Zealand is a magnificent volume carefully illustrated. The fidelity of the drawings is remarkable.

The last of the gardens in New Zealand visited by me was that at Wellington. It is situated on the hill back of the city, and possesses chiefly the characteristics of a park.

Dunedin, Christchurch, and Wellington, to which we may add also Auckland, have excellent local museums. The one at Dunedin is growing rapidly in the direction of zoology. This is under the charge of Professor T. Jefferey Parker. Christchurch museum is widely known from the collections of bones of extinct birds which were brought together by the late Dr. Julius von Haast. The museum is extensive in many departments, particularly ethnology, but it needs re-arrangement. This it will doubtless receive soon from its new curator, Dr. H. O. Forbes, the naturalist whose studies in the Eastern Archipelago are familiar to all our readers. The cathedral city of Christchurch is the home of Professor Hutton of Canterbury college. Wellington is the capital of New Zealand. Its museum is extensive, but inadequately provided with proper exhibition rooms. The display of ethnological specimens is exceedingly good, being arranged in the most effective manner. The Auckland museum is also rich in ethnological specimens.

I have purposely deferred to the last, a brief description of the local museum at Hobart, Tasmania. Mr. Alexander Morton, the curator, has carried out to the furthest extent his plan of establishing a Tasmanian exhibition. In the first place, it is comprehensive, taking in all departments of natural history, as well as geology, archæology and ethnology, in other words, natural history in the widest sense. As a rule, specimens from other places are used wholly for comparison. The arrangement in each department is simple and perfectly intelligible to the person of average intelligence, and each specimen is very fully described on its label. Almost every museum in all Australasia seeks rightly to make the exhibits attractive and instructive, especially in the line of local matters. The collections at Hobart are therefore only a conspicuous example of what can be done on a small scale and with very limited means.

Another characteristic of all the Australasian museums is highly commendable, namely the tenacity with which they all cling to rare specimens of archæological and ethnographical interest, instead of utilizing them for exchange. Those of us who deplore the disintegration of collections will sympathize heartily with the policy adopted in the South.

By and by, the time will doubtless come when, under some system of federation, a capital city for all the colonies will be selected, in which a central museum may gather for comparison all the rarer of these now scattered treasures, but it is to be hoped that none of these which are unreplaceable will be suffered to leave the country, at least until the fragmentary history of the fast vanishing races is secured. This was impressed upon the writer on his visit to one of the museums before alluded to, in which there was a fairly large collection of ceremonial knives and weapons. The curator pointed out the slight differences existing between the allied groups and stated that some of the types of manufacture are no longer to be met with, in a genuine form. It is worthy of note that excellent imitations of some of the rarer types are to be obtained of dealers, but it is seldom that genuineness is claimed even for the cleverest of the copies.

Frequent reference has been made in these papers to the very general interest felt by the Australasian public in matters pertaining to applied science. It is because of this widespread interest that the botanic gardens and museums are so well sustained. Further, it is on this account that the various institutions which deal with technology, as in Adelaide, Melbourne, and Sydney, are generously supported. There are certain social and economic factors which render it less easy than might be supposed, to give to these and kindred institutions all the aid they need; taking these factors into consideration, it must be confessed that practical scientific education receives in the southern hemisphere a greater degree of attention than it does in the northern: far greater when we take into account the comparatively small population of Australasia.

Before leaving the subject of the gardens of the South, it will not be deemed out of place to refer to the excellent private gardens found in all the larger towns. The writer enjoyed the privilege of visiting some of the finer of these collections, a few of which contained specimens which would be considered real acquisitions by any amateur horticulturist in the world.

A sketch of the Queensland Coast will come most conveniently in the fourth paper of this series. G. L. G.

IV. Miscellaneous Scientific Intelligence.

1. *American Association for the Advancement of Science.* Fortieth Meeting, at Washington.—The meeting was opened on the 19th of August, under the Presidency of Prof. Albert B. Prescott, of Ann Arbor, Michigan. The valuable address of the

retiring President, Prof. Goodale, on some of the Possibilities of Economic Geology makes the opening article of this number.

The Vice-Presidents of the sections appointed are the following. A, Mathematics and Astronomy, Prof. J. R. Eastman, of the Naval Observatory, Washington; B, Physics, Prof. B. F. Thomas, State University, Columbus, Ohio; C, Chemistry, Dr. Alfred Springer, Cincinnati; D, Mechanical Science and Engineering, Prof. J. B. Johnson, Washington University, St. Louis; E, Geology and Geography, Prof. H. S. Williams, Cornell University; F, Biology, Prof. S. H. Gage, Cornell University; H, Anthropology, W. H. Holmes, Ethnological Bureau, and I, Economical Science and Statistics, Prof. S. Dana Horton, Pomeroy, Ohio.

Prof. Putnam is continued as Permanent Secretary. Rochester, New York, was selected as the next place of meeting.

List of papers accepted for reading.

Section A. Mathematics and Astronomy.

A. S. CHRISTIE: A digest of the literature of the mathematical sciences.

C. L. DOOLITTLE: Latitude of the Sayre Observatory.

G. C. COMSTOCK: The secular variation of terrestrial latitudes.

G. W. HOLLEY: Groups of stars, binary and multiple.

J. A. BRASHEAR: Description of the great spectroscope and spectrograph, constructed for the Halstead Observatory, Princeton, N. J. Note on some recent photographs of the reversal of the hydrogen lines of solar prominences.

FRANK H. BIGELOW: Standardizing photographic film without the use of a standard light. Exhibition and description of a new scientific instrument, the aurora-inclinometer.

DAVID P. TODD: On a modified form of zenith telescope for determining standard declinations. On the application of the "photochronograph" to the automatic record of stellar occultations, particularly dark-limb emersions.

O. T. SHERMAN: The zodiacal light as related to terrestrial temperature variation.

ORMOND STONE: On the long-period terms in the motion of Hyperian.

A. MACFARLANE: Principles of the algebra of physics.

HENRY M. PARKHURST: The tabulation of light-curves; description, explanation, and illustration of a new method. Stellar fluctuations; distinguished from variable stars; investigation of frequency.

THOMAS S. FISKE: On certain space and surface integrals.

J. LOUDON: The fundamental law of electromagnetism.

F. P. LEAVENWORTH: Method of controlling a driving clock.

WM. E. HEAL: On the bitangential of the quintic.

J. E. KEESHNER: Parallax of α Leonis.

Section B. Physics.

WILLIAM HOOVER: On the logarithmic mean distance between pairs of points in any two lines.

E. W. MORLEY: A new method for measuring the expansion of solids.

E. W. MORLEY and W. A. ROGERS: Measurement of the expansion of Jessop's steel by a new method.

GUSTAVUS HINRICHS: Statement of the general law determining the fusing and boiling point of any compound under any pressure as simple function of the chemical constitution of the same. The calculation of the boiling point of a liquid under any pressure. Determination of the discontinuity of the fusing points of paraffins by means of analytical mechanics.

WILLIAM ORR: A scheme for a science of color.

B. F. THOMAS: Note on magnetic measurements at Ohio State University. Notes on rotating contact methods of measurement of variable electric magnitudes.

M. A. VEEDER: The periodicity of the Aurora.

C. B. THWING: Color photography by Lippmann's process. Behavior of silver emulsions under long exposure to light.

A. MACFARLANE: On the nomenclature for physical units.

A. MCADIÉ: Some experiments in atmospheric electricity.

W. M. STINE: Some forms of carbon and alkaline storage batteries. The tangent galvanometer as a voltmeter.

H. A. HAZEN: Do tornadoes whirl? Artificial rain.

N. H. GENUNG and F. J. ROGERS: Observations with a new photometer.

F. J. ROGERS: Magnesium as a source of light.

BROWN AYRES: Note on the measurement of resistances by alternating currents. The nature of "counter-electromotive force." What should be our fundamental units?

Section C. Chemistry.

CHAS. L. REESE: Preliminary notes on the influence of swamp waters on the formation of the phosphate nodules of South Carolina.

E. T. COX: Land and river phosphate pebbles or nodules of Florida.

ALFRED SPRINGER: A latent characteristic of aluminum.

PAUL C. FREER: The influence of negative atoms and groups of atoms on organic compounds.

E. GOLDSMITH: Gabbro phonolyte.

H. A. WEBER: Raphides the cause of the acridity of certain plants.

GUSTAVUS HINRICHS: The calculation of the boiling point of a paraffin under any pressure. The calculation of the boiling points of isomerics from their moment of inertia. Determination of the true position of the carbon atoms in organic compounds by means of analytical mechanics.

F. P. DUNNINGTON: Distribution of titanic oxide on the earth's surface.

THOMAS TAYLOR: The precipitation of fish oil in linseed oil, when used as an adulterant, by silver nitrate solution. The separation and precipitation of oleic acid from linseed oil by silver nitrate.

WALTER MAXWELL: Biological functions of the lecithins.

EDWARD W. MORLEY: Synthesis of weighed quantities of water from weighed quantities of oxygen and hydrogen.

EDWARD HART: Dinitro-sulfo-phenol.

W. M. STINE: Continuous-feed apparatus for distilling water.

C. L. SPEYERS: The atomic theory.

P. L. SPENCER and E. E. EWELL: Imitation coffees.

H. W. WILEY and W. H. KING: The composition of floridite.

WM. H. SEAMAN: Tri-nitro toluene, a substitute for musk.

L. P. KINNICUT: Purification of Worcester sewage by chemical precipitation. Fire clay from Mount Savage.

W. A. CHAPMAN: An inquiry relative to the causes leading to the formation of ore deposits.

J. G. SPENZER: Delicacy of the tests for phenol.

J. U. NEF: An aceto-acetic ether.

W. S. YEATES: On plattnerite from Idaho.

E. A. v. SCHWEINITZ: The chemistry of some disease germs. A convenient arrangement for a Pasteur filter, where air pressure is available.

H. W. WILEY: Notes on pinite. Notes on the chemical composition of muck soil from Florida. Composition of crystalline artificial calcium phosphate.

J. THOMAS DAVIS: Meat preservatives.

W. H. KING: Determination of phosphoric acid in presence of iron and alumina.

Section D. Mechanical Science and Engineering.

JAMES E. DENTON: Economy produced by the use of water injected as a fine spray into air compressors. Note on the efficiency of the screw propeller. On a method of holding samples of wood and brick for determination of tensile strength. Relative economy of compound and triple expansion engines.

DAVID P. TODD: On experimental results obtained with a new form of direct-action propeller.

B. E. FERNOW: The Government timber tests.

JOHN B. JOHNSON: The United States tests of American woods, made at the Washington University Testing Laboratory.

CHAS. L. BOUTON: On the crushing of short prisms of homogeneous material.

THOMAS GRAY: On expansion steam calorimeters. Tests of electric railway plant. On the power absorbed in the cutting of metals.

D. S. JACOBUS: Maximum error due to neglecting the radiation-correction of a Barrus universal calorimeter. Relative economy of carbonic acid as the working fluid of refrigerating machines.

WILLIAM KENT: On the efficiency of the steam jackets of the Pawtucket pumping engine. On the opportunity for mechanical research at the World's Fair.

Section E. Geology and Geography.

JOHN T. CAMPBELL: Source of supply to lateral and medial moraines.

A. E. FOOTE: New meteoric iron from Arizona containing diamonds.

G. K. GILBERT: Post-glacial anticlinal ridges near Riply and Caledonia, New York.

WARREN UPHAM: Processes of mountain building and their relationship to the earth's contraction.

HENRY LAMPARD: Notes on an extinct volcano at Montreal, Canada.

E. D. COPE: (A) On a new horizon of fossil fishes. (B) On the cranial characters of *Equus excelsus* Leidy.

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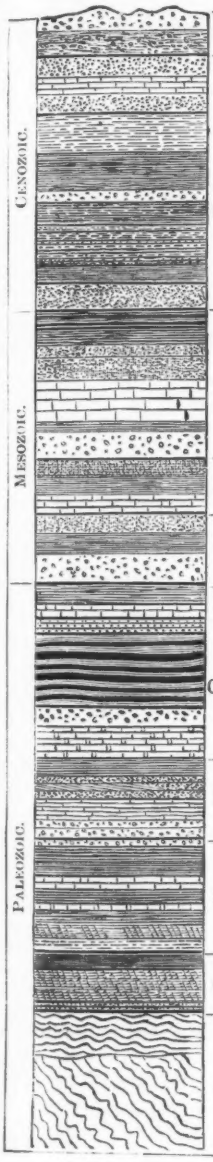
2. *The British Association.*—The meeting of the British Association was opened at Cardiff, Wales, on Wednesday, the 19th of August. The able address of the President, Professor William Huggins, treating of the progress of Astronomy through spectroscopic observations, is published in full in Nature of August 20th. The reader is referred to this and the following numbers of Nature for the addresses, also of the Presidents of Sections, and for abstracts of the more important papers presented. The next meeting will be held at Edinburgh, under the Presidency of Sir Archibald Geikie, commencing on the 3d of August, 1892.

OBITUARY.

WILLIAM FERREL, the eminent meteorologist, died at his home in Kansas City, Missouri, on the 18th of September, at the age of seventy-four. He commenced his active scientific career in 1857, when he was made assistant in the office of the American Ephemeris and Nautical Almanac. This position he held for ten years, when he was appointed to the staff of the U. S. Coast Survey. In 1882 he was made assistant, with the rank of professor, in the Signal Service Bureau, where he remained until October, 1886. Some of his most important work was was done in connection with the Coast Survey; he invented the maxima and minima tide-tide predicting machine, which is now used in predicting the tides. His list of published works include a number of volumes devoted to researches on the tides, meteorological problems, etc.; of these, a volume on Recent Advances in Meterology was published in 1883, and a Popular Treatise on the Winds—a work of marked value—in 1889. The recent volumes of this Journal contain a number of important memoirs by Mr. Ferrel upon thermal radiation, cyclones, tornadoes and related subjects, chiefly in terrestrial physics.



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			Phohippus Beds.	*Phohippus, Tapiravus, Mastodon, Procamelus, Aceratherium, Bos, Moropus.*
		Miocene.	Miohippus Beds.	*Miohippus, Diceratherium, Thinohyus.*
			Oreodon Beds.	*Oreodon, Eporeodon, Hyænodon, Hyracodon, Moropus.*
			Brontotherium Beds.	*Brontotherium, Brontops, Allops, Titanops, Titanotherium, Protoceras, Mesohippus, Elotherium.*
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			Coryphodon Beds.	*Coryphodon, Eohippus,* Lemurs, Ungulates, Tillodonts, Rodents, Serpents.
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			Fox Hill group.	
			Colorado Series, or Pteranodon Beds.	Birds with Teeth, *Hesperornis, Ichthyornis.* Mosasaurs, *Edestosaurus, Lestosaurus, Tylosaurus.* Pterodactyls (*Pteranodon*). Plesiosaurs.
			Dakota Group.	
	Jurassic.		Atlantosaurus Beds Baptanodon Beds. Hallopus Beds.	Dinosaurs, *Brontosaurus, Morosaurus, Diplodocus, Stegosaurus, Camptonotus, Allosaurus.* Mammals, *Dryolestes, Stylacodon, Tinodon, Ctenacodon.*
	Triassic.		Otozoum, or Conn. River, Beds.	First Mammals (*Dromatherium*). Dinosaur Footprints, *Anchisaurus, Ammosaurus.* Crocodiles (*Belodon*).
PALEOZOIC.	Permian.		Nothodon Beds.	Reptiles (*Nothodon, Sphenacodon*).
	Carboniferous		Coal Measures, or Eosaurus Beds.	First Reptiles (?) *Eosaurus.*
			Subcarboniferous, or Sauropus Beds.	First known Amphibians (Labyrinthodonts), *Sauropus.*
	Devonian.		Dinichthys Beds.	*Dinichthys.*
			Lower Devonian.	
	Silurian.		Upper Silurian.	
			Lower Silurian.	First known Fishes.
	Cambrian.		Primordial.	
	Archæan.		Huronian.	No Vertebrates known
			Laurentian.	

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J. WILEY & SONS, New York.—**Treatise on Mineralogy,** by J. D. DANA. 5th edit. xlviii and 828 pp. 8vo., 1868. $10.00. The 5th "subedition" was issued by Wiley & Son in April, 1874. (Each "subedition" (or issue from the stereotype plates), contains corrections of all errors discovered in the work up to the date of its publication). Also, Appendix I. by G. J. Brush, 1872. Appendix II, 1875. Appendix III, 1882, by E. S. Dana.—**Manual of Mineralogy & Lithology,** by J. D. DANA. 3d edition. 474 pp. 12mo., 1878.—**Text-book of Mineralogy,** by E. S. DANA. Revised edition. 512 pp. 8vo., 1883.—**Text-book of Elementary Mechanics,** by E. S. DANA. 300 pp. with numerous cuts, 12mo., 1881.—**Manual of Determinative Mineralogy,** with an Introduction on Blow-pipe Analysis, by GEORGE J. BRUSH. 8vo., 2d ed. 1877. Third Appendix to Dana's Mineralogy, by E. S. DANA. 136 pp. 8vo. 1882.

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